SCIENCE ABSTRACTS.

Section A.—PHYSICS.

DECEMBER 1913.

GENERAL PHYSICS.

1922. *A Quartz Pendulum.* **M. Schanzer.** (Zeitschr. Instrumentenk. 33. pp. 277–279, Sept., 1913.)—It is claimed that vitreous silica has advantages over invar as the material for the shaft of a standard pendulum. The details of construction of such a pendulum are given. P. E. S.

1923. *A Fuller Test of the Law of Torsional Oscillation.* **J. B. Ritchie.** (Roy. Soc. Edinburgh, Proc. 33. pp. 177–182, 1912–1913.)—Examines the effect of modifying, by a closer approximation, the equation $y^n (x + a) = b$, which represents the law of decrease of torsional oscillations in wires [see Abstract No. 1310 (1911)]. On plotting results for Cu a curve of form similar to that given by the original equation is obtained, and it is concluded that no improvement is introduced by taking the more accurate form. J. W. T. W.

1924. *Continued Investigation of the Application of the Law of Torsional Oscillation.* **J. B. Ritchie.** (Roy. Soc. Edinburgh, Proc. 33. pp. 183–193, 1912–1913.)—Describes a continuation of former experiments [see Abstract No. 1310 (1911)] made upon eight metals: brass, Au, Pt-Ir, Pt, assay silver, Al, Cu, and German silver. Three alloys of Cu and Al satisfied the general equation [see preceding Abstract], while one of Al and brass was found which did not change its behaviour after heating. Magnetisation of an iron wire produced a gradual but irregular increase in one only of the constants for the wire. A compound wire (Zn electrolytically deposited on Cu) gave results lying between those for the constituent metals. J. W. T. W.

1925. *Deviation of the Torsional Oscillations of Metallic Wires from Isochronism.* **W. Peddie.** (Roy. Soc. Edinburgh, Proc. 33. pp. 225–242, 1912–1913.)—In former papers (Ibid. Trans., 1898; Phil. Mag., 1894) it was shown that the period of the inward oscillation of an iron wire was distinctly greater than the period of its outward oscillation over the same range, and that the complete period was slightly greater when the range was relatively great than when it was small. In these respects the material deviated from the conditions of isochronism that are characteristic of the simple harmonic vibrations of a material which practically follows Hooke's law during distortion. Since the method of observation formerly employed did not give much more than qualitative results and was quite inadequate for the determination of the actual law of oscillation at all stages, a different method has been employed in the work which constitutes the subject-matter of the present paper. A description of the method and of the apparatus is first given at some length, accompanied by diagrams and curves whereby the experimental results are shown for the cases of three different materials, viz. iron, copper, and zinc, and the nature of their deviation from those characteristic of simple harmonic motion is exhibited. The correspondence of the small oscillations of an elastic material, such as steel, with the simple harmonic law is well known, but it seems to be a very remarkable thing that, in the case of a substance possessing so great viscosity (the term viscosity being used here merely to indicate internal resistance to relative motion of the parts) that the amplitude falls to one-half of its initial value in a single semi-oscillation, the law of oscillation should be very accurately simple harmonic from the extremity of the range inwards to the position of set (inflection), beyond that to the zero point, and almost as far beyond the zero on the negative side as the position of set is separated from it on the positive side. After that stage is reached, the deviation from the simple harmonic law takes place very rapidly. The result is very significant in connection with the view of G. Wiedemann, that the loss of energy is due to the work done in shifting the position of set from one side of the zero point to the other. Its possibility was suggested by the theoretical discussion which the author next gives of a molecular condition under which the observed laws of torsional oscillation might be simulated. This theoretical treatment is based upon the experimental results and the established fact that the law of the decrement of the range, y, of oscillation, as the number of oscillations, x, increases, is very accurately given by the relation $y^n (x + a) = b$, where n, a, and b are constants, together with other known facts regarding the statical and kinetic laws of deformation of a solid, *e.g.*, those of "set." Any theory must be of "molecular" type, the loss of energy being, in great part at least, due to the rupture of molecular configurations, which latter may take place on a finite "crystalline" scale. The author summarises the results of his investigations as follows :—(1) The oscillations of a viscous wire exhibiting set are simple harmonic with regard to the position of set throughout the whole range of the in-motion and a considerable part of the out-motion. In the remainder of the out-motion the deviation from the simple harmonic condition is great. (2) The period of in-motion to the zero is distinctly greater than that of the out-motion from it. (3) A theoretical deduction of these results, and of the law of loss of energy per oscillation, can be founded on the assumption that that loss is due to the rupture of strained molecular (which may be finite crystalline) groups. (4) A sudden change in the oscillation parameters when the decreasing maxima pass through a definite magnitude is explainable by the existence of a dominant type of groups which cease to rupture when the decreasing strain reaches a definite value; and the known peculiar temperature and stress effects are explainable as depending on well-recognised conditions of structural changes. H. H. Ho.

1926. *Strength of Hooks and Curved Beams.* (Engineering, 96. pp. 307–309, Sept. 5, 1918.)—The mathematical investigation of the stresses in hooks and curved beams published by E. S. Andrews and K. Pearson in a Drapers' Company Research Memoir, 1904, is criticised on account of the extreme complexity of the formula attained, and because this formula does not appear to give very accurate results for the stresses. The complete argument would be useless if materially abbreviated, but the principal assumption wherein lie the differences between the present discussion and that of Andrews and Pearson is that those authors assumed that stresses which were zero at the surface of the beam were zero throughout the section; this it is shown is not true, because the radial stress attains a value which may be considerable when the ratio of the inner to the outer radius, r_0/r_1, is small. Instead the convenient assumption is made that the contribution of these transverse stresses to the resilience of the beam is practically constant for all reasonably probable distributions of the tangential stresses. The resulting approximation is $Q = k + l/r$, for the tangential stress, Q, which, as a table shows, gives much closer results than the formula of Andrews and Pearson; k and l are determined by the relations $k\bar{r} + l = M/\Omega$, and $k\Omega + l\int_{r_0}^{r_1} z/r \, . \, dr = 0$. The integral $\int z/r \, . \, dr$ is found for any section graphically or by other approximate method, Ω is the area of cross-section, $\bar{r}$ the distance of its centre of gravity from the centre of curvature, z is the breadth of the layer at radius r, M is the bending moment. F. R.

1927. *Viscosity of Anisotropic Liquids.* **F. Krüger.** (Phys. Zeitschr. 14. pp. 651–655, July 15, 1918.)—Anisotropic liquids and emulsions show a complete mutual analogy in the dependence of their viscosity upon pressure. Since no molecular peculiarities would account for this analogy [see Bose, Abstract No. 208 (1909)], it must be inherent in liquids generally. Sorkau distinguishes three states of turbulence, which Mie has shown to be reducible to two. In the normal viscous flow (Poiseuille) the temperature coefficient of viscosity is characteristic for each substance. In the first turbulent state (Reynolds) the temperature coefficient is nearly the same for all substances, while in the second turbulent state, in which the liquid passes through the capillary like a solid rod covered by a liquid film, there is practically no change with temperature. Bose's "swarm theory" may be a true statement of many molecular facts, but it cannot now be called upon to explain the dependence of viscosity upon pressure. E. E. F.

1928. *Determination of Capillary Constant in Molten Solids by Means of Dimensions of Drops.* **A. Ignatiev.** (Jurn. Russk. Fisik.-Chimičesk. Obščestva, 44. 2. pp. 71–78, 1912.)—Finding Kasterin's formula (Ibid. 25. p. 208, 1898) imperfect, the author used the following:—

$$a^2 = \tfrac{1}{2}h^2 - d \, . \, a^2h/L + 2a^2h/b,$$

where a^2 capillary constant, h = vertical distance between summit and greatest horizontal section of drop, $2L$ = greatest drop diam., b = radius of drop at summit, d = const. = 0·61.

$$a^2 = \tfrac{1}{2}h^2/[-h(2/b - d/L)] = \tfrac{1}{2}h/1.$$

b is taken as $= \tfrac{1}{2}(u/z)$, where u and z are the co-ordinates of points in the drop's outline near its summit. Experiments were carried out as follows:—On an horizontal table 12 pieces of glass were placed on which 12 lumps, of different dimensions, of the materials were put (after being cooled down and split).

Between the lumps of material on the glass were put up rods, the heights of which were correctly measured. The material melted on the glass and took the form of flattened drops. These drops were then photographed together with the rods. With a dividing machine and microscope the distance (h_1) from the summit of the drops to the greatest horizontal section was determined, also the measurement of the rods. From the correct heights of the rods a true scale of photograph was determined with a correct calculation for h. In the same manner also 2L was determined. To correctly define b the co-ordinates u and z for the different drops were determined by projecting a greatly enlarged image of the outline of the drops. The average value obtained for a^2 is $5{\cdot}60 \pm 0{\cdot}05$, comparing with Landolt and Börnstein's tables, showing :—

	a^2.	t°.
Spermaceti	7·9	44
Sweet oil	7·8–7·7	20
Wax	7·1	68
Petroleum..................	6·5	25
Turpentine... $s = 0{\cdot}89$	6·1	20
Turpentine... $s = 0{\cdot}98$	5·8	20

The temperature during the duration of test ranged between 14° and 24°.

I. P.

1929. *Experiments with Rotating Liquid Films.* **C. V. Boys.** (Roy. Soc., Proc. Ser. A. 87. pp. 340–350, Oct. 2, 1912.)—A description of a number of beautiful experimental effects obtained with the aid of an apparatus consisting of a rotating cylindrical cup with inturned rim, on which a soap film is stretched. The apparatus is the same as that now being sold under the name of the "Rainbow Cup," and a fuller account is to appear in the form of an additional chapter to the author's book on "Soap Bubbles." L. H. W.

1930. *Constitution of Atoms and Molecules.* **N. Bohr.** (Phil. Mag. 26. pp. 1–25, July, 1913.)—The starting-point of this inquiry is Rutherford's hypothesis of atomic constitution [Abstract No. 1347 (1911)]. In Thomson's atom-model the radius of the sphere of positive electrification provides a constant having the dimensions of a length, and of the same order of magnitude as the linear extension of the atom, and so the model allows of certain stable configurations and motions. The author's primary aim is to show that the introduction of Planck's constant, the elementary quantum of action, will serve, in Rutherford's model, to take the place of the radius of the positive sphere, and so make stability possible.

First consider a single electron, negligibly small compared with the positive nucleus, and with a velocity small compared to that of light. Let $-e$ be the charge of the electron, m its mass, and E the charge of the nucleus. If no radiation the orbit will be a stationary ellipse with frequency ω and semi-major axis a, such that $\omega = \sqrt{2}/\pi \,.\, W^{\frac{3}{2}}/eE\sqrt{m}$, $2a = eE/W$; where W is the energy required to separate the electron to an infinite distance from the nucleus, which can be shown to equal the mean kinetic energy of the electron taken for a whole revolution. Taking account of radiation, W will continually increase and a diminish, while ω will increase, the electron gaining in mean kinetic energy as the whole system loses energy. This will continue until the dimensions of the orbit are of the same order of magnitude as those of the electron or of the nucleus, and during its continuance the radiation is enormously greater than in ordinary molecular processes. Assume that the reaction between nucleus and electron started at a great distance apart and with no sensible relative velocity, and that when complete the orbit is stationary and circular. Assume further that during this binding of the electron the radiation is homogeneous and of frequency ν, equal to half the final revolution frequency as suggested by the initial revolution frequency being 0. Then, on Planck's theory, the energy emitted during the process should be $\tau h\nu$, where τ is an integer, and h is Planck's constant. Then, substituting $W = \tau h\omega/2$, we have—

$$W = 2\pi^2 me^2E^2/\tau^2h^2,\ \omega = 4\pi^2 me^2E^2/\tau^3h^3,\ 2a = \tau^2h^2/2\pi^2me.$$

W will then be greatest, and the system most stable, for $\tau = 1$. Substituting this, the experimental values for e, e/m, and h, and putting $E = e$, we get—

$$2a = 1{\cdot}1 \times 10^{-8}\ \text{cm.},\ \omega = 6{\cdot}2 \times 10^{15}\ (\text{sec})^{-1},\ W/e = 13\ \text{volts},$$

which are of the same order as the linear dimensions of the atoms, the optical frequencies, and the ionisation potentials respectively.

The author briefly criticises the atomic systems proposed by J. W. Nicholson in view of Planck's theory [Abstracts Nos. 155, 449, 1643, 1644 (1912), and 365 (1913)], stating that, apart from objections which may be only formal, they do not appear capable of accounting for the laws of Balmer and Rydberg connecting the frequencies of the lines in the line spectra of the ordinary elements, and claims that his theory provides a solution, and further, that his special assumptions may be modified, retaining the fundamental ones:—that the dynamical equilibrium of the systems in the stationary states can be discussed in terms of the ordinary mechanics, but not so during passage between two such states; and that such a passage is followed by the emission of homogeneous radiation for which the relation between the frequency and the energy emitted is that of Planck's theory. General evidence indicates that the atom of hydrogen is of the kind considered above, and here $W_\tau = 2\pi^2me^4/h^2\tau^2$, so that equating the energy emitted in passing from τ_1 to τ_2 to $h\nu$ gives $\nu = 2\pi^2me^4/h^3 . (\tau_2^{-2} - \tau_1^{-2})$. This gives the Balmer series for $\tau_2 = 2$, while τ_1 varies. $\tau_2 = 3$ gives the series in the ultra-red suspected by Ritz and observed by Paschen [Abstract No. 235 (1909)]. $T_2 = 1, 4, 5$, gives series in the extreme ultra-violet and ultra-red, which have not been observed, but the existence of which may be expected. And the agreement is quantitative as well as qualitative, for, by calculation, $2\pi^2me^4/h^3$ has the value $3{\cdot}1 \times 10^{15}$, while the observed value is $3{\cdot}290 \times 10^{15}$, a difference within the limits of experimental error in determining the constants in the theoretical expression. Moreover, the theory shows that small gaseous density is essential to appearance of many lines, and simultaneously to obtain an intensity sufficient for observation the volume of gas available must be very great, which would explain why 33 Balmer lines are observed in some celestial spectra, and not more than 12 in vacuum tubes.

The lines observed by Pickering and Fowler, and generally attributed to hydrogen, are not accounted for, but the author shows that they could be accounted for as arising from helium, and suggests that this may be the case. For systems containing more than one electron the detailed discussion will probably be very complex, but the frequency being expressible as a difference between two functions of integers suggests an origin of the spectra similar to that assumed for hydrogen. Moreover, the presence of the universal constant K in Rydberg's formula will follow for a spectrum corresponding to radiation emitted during the binding of an electron, provided the system, including that electron, is neutral, for in that case for high values of τ,

$$\mathrm{Lim}(\tau^3 . F_1(\tau)) = \mathrm{Lim}(\tau^3 . F_2(\tau)) = \ldots = 2\pi^2 me^4/h^3.$$

The assumption hitherto made that different stationary states correspond to different numbers of energy quanta is improbable, for the frequency is a function of the energy and will therefore be changed by emission of a quantum, and the author shows that the results are unchanged when the equation $W = \tau h\omega/2$ is interpreted as meaning that the frequency of the energy emitted during the passing of the system from a state of no radiation to one of the different stationary states is equal to different multiples of $\omega/2$. Further, the values for W, ω, and a, provided the electron orbit be circular in a stationary state, merely express the condition that in such a state the angular momentum of the electron round the nucleus is an integral multiple of a universal value, independent of E. The permanent state is then that for which $\tau = 1$. To account for Kirchhoff's law in radiation during passage between stationary states A_1, A_2, the necessary conditions for such emission is the presence of systems in state A_1, and for absorption, the presence of systems in state A_2. This agrees with experiment, *e.g.*, absence of absorption of line spectrum radiation in hydrogen, for emission was found to occur in passages for which $\tau \geqq 2$, while the permanent state is for $\tau = 1$, and the author shows how other experimental results are accounted for.

Rutherford's calculations of energy of β-particles [Abstract No. 483 (1913)] suggest that an electron traversing an atom at high velocity liberates energy in quanta in collisions with the electrons of the atom, and the absence of equipartition of energy between free electrons and those bound in atoms demands explanation. This we find, with that of Rutherford's results, in the assumption that two colliding electrons, bound or free, will, after collision as before, be in stationary, or *mechanical*, states. The bound electron could not, therefore, acquire less than the difference in energy corresponding to successive stationary states, and so the free colliding electron could not lose less.

The small dissociation of hydrogen molecules at ordinary temperatures necessitates consideration of more complex molecules for further comparison with experimental results. The author then shows that to proceed from system of single electron in circular orbit to ring of n electrons we merely have to substitute $E - es_n$ for E, where—

$$s_n = \sum_{s=1}^{s=n-1} \operatorname{cosec} \frac{s\pi}{n}.$$

Then, assuming the binding of the electrons to come about as before, the configuration for greatest energy emission will again be for $\tau = 1$, to be taken as the permanent state. The author considers that line spectra of systems with more than one electron require existence of states brought about also in other ways, but none corresponding to greater energy emission than the one here taken as permanent. Stability is assumed to be secured through the universal constancy of the angular momentum, together with the assumption that the configuration is that in formation of which most energy is emitted, which is found equivalent to that ordinarily made so far as displacements perpendicular to the place of the ring are concerned. The difference in the laws of ordinary line spectra and those found by Nicholson for coronal spectra may arise from the latter being due to scattering, and not true emission, of radiation—a natural assumption since the extreme rarefaction would result in few collisions to disturb the stationary state.

The author then enunciates, as capable of simple proof, the theorem :—"In every system consisting of electrons and positive nuclei, in which the nuclei are at rest and the electrons move in circular orbits with a velocity small compared to the velocity of light, the kinetic energy will be numerically equal to half the potential energy." Hence he generalises his atomic hypothesis into the form :—In any molecular system consisting of positive nuclei and electrons in which the nuclei are at rest relative to each other and the electrons move in circular orbits, the angular momentum of every electron round the centre of its orbit will in the permanent state of the system be equal to $h/2\pi$, where h is Planck's constant. G. W. DE T.

1931. *Determination of Aqueous Vapour above Mount Wilson.* **F. E. Fowle.** (Astrophys. Journ. 37. pp. 359–372, June, 1913.)—The amount of aqueous vapour in the atmosphere was determined by the spectro-bolometric method described in an earlier paper [see Abstract No. 1525 (1912)]. The experiments discussed in the present paper were made on certain days in the years 1910 and 1911. The average quantity of precipitable water present was 0·69 cm., with a range from 0·2 cm. to 2·8 cm. Hann gives the formula $Q_w = 2{\cdot}3e_w$ connecting the vapour pressure e_w, at the earth's surface with the depth of precipitable water in the atmosphere, Q_w. Correcting this for the altitude of Mount Wilson above sea-level (1730 m.) the formula becomes $Q_w = 1{\cdot}9e_w$. Humphreys finds a value of 1·7 for this constant. The mean value from the present author's experiments is 1·8, but individual values vary from 0·3 to 11·8; so that the formula, though applicable to mean conditions, cannot be regarded as of any value for individual days. J. S. DI.

1932. *Difference of Temperature between the Free Air and the Air on Mountain Summits.* **H. v. Ficker.** (Meteorolog. Zeitschr. 30. pp. 278–289, June, 1913.)—The summit taken for the comparison is Zugspitze (2964 m. above sea-level). Observations of free air temperatures were derived either from results of ascents of manned balloons starting from Innsbruck or from ascents of registering balloons from Munich. The results of the comparisons are : (1) At 7 a.m. the Zugspitze is always colder than the free atmosphere at the same height. At 2 p.m. the difference is nil or very small. (2) The differences are least in calm weather. (3) The result of the comparison cannot be taken as applying to the whole of the Alpine mountain-peaks without further investigation. (4) With an upward current the difference is small if condensation is taking place at the Zugspitze level ; otherwise it is greater. Rising currents are usually associated with winds having northerly components on account of the main mass of the Alps lying to the south. (5) The difference is greatest with a downward current, *i.e.* with a wind having a southerly component. R. C.

1933. *Studies of the Nocturnal Radiation to Space.* **A. Ångström.** (Astrophys. Journ. 37. pp. 305–321, June, 1913.)—The paper has four parts : (1) An historical review of the subject. (2) Theoretical considerations. (3) An account of the instrument used by the author in his experiments, and (4) A discussion of the results obtained. Little work has been done on the outward radiation to space in comparison with that which has been devoted to the incident solar radiation, so that present knowledge of the subject is very incomplete. The observations of the author were made on the loss of heat of a black body exposed at night to the complete hemisphere of the sky. It is pointed out that this is made up of the outward (positive) radiation to space determined by Stefan's law, together with the inward (negative) radiation from the gases of the atmosphere and sidereal sources. The instrument employed was a suitably modified form of the well-known Ångström pyrheliometer. The loss of heat (R) in cals. per cm.^2 per min. from a black body freely exposed at night at Bassour, Algeria, was found to be connected with the surface vapour-pressure p (mm.) by the equation $R = 0{\cdot}109 + 0{\cdot}184e^{-0{\cdot}10p}$. This equation may not hold without modification for temperatures which differ widely from those experienced at the time and place of these experiments. J. S. Di.

1934. *Air in the Depths of the Ocean.* **C. Juday.** (Science, 38. pp. 546–547, Oct. 17, 1913.)—The author commences by pointing out that the suggestion in recent communications on this subject as to diffusion being the sole agent involved in the aeration of ocean depths is untenable, since it only plays a negligible rôle. The atmospheric gases only diffuse very slowly through water, the coefficient of nitrogen being 1·73, of oxygen 1·62, and of CO 1·38, while the rapidity with which oxygen is transferred is well illustrated by Hüfner's computations for Lake Constance which has a max. depth of about 250 m. The latter are: (1) That it would take oxygen about 42½ years to pass from the surface to the bottom by diffusion alone; (2) that over 100,000 years are required for the quantity of oxygen which its waters are capable of holding at 10° C. to diffuse into a body of water of equal area and unlimited depth; (3) that under natural conditions, with the depth limited to 250 m., it would require over a million years for this body of water to become saturated at the above temperature if it had no dissolved oxygen and acquired a supply only by diffusion from the atmosphere. Again, if ocean waters were aerated solely by diffusion the upper strata should possess a larger amount of dissolved oxygen than the lower, which is not actually the case. Other examples are quoted to illustrate the fact that some other agent than diffusion is responsible for the aeration of bodies of water. The author suggests that in lakes aeration is accomplished by the vernal and autumnal overturning of the water and its subsequent circulation for a longer or shorter period. In the case of ocean waters Helland-Hansen states that "gases are absorbed at the surface from the atmosphere and are carried by currents even into the deepest parts of the ocean in varying amounts." H. H. Ho.

1935. *Solar Magnetism.* **K. Birkeland.** (Comptes Rendus, 157. pp. 104–106, July 15, 1913.)—The author sets out to prove that the emission of ions and electrons from the sun produces an increase of solar magnetism up to a certain point, and that the field may either have the sense of the earth's direction, or, as the author has deduced [see Abstract No. 448 (1910)], the converse sense. He takes the case of a magnetic sphere emitting corpusclar radiations, where from polar regions the radiation may escape to infinity by passing sufficiently near the lines of magnetic force, while equatorially the magnetic force is normal to the orbit of the radiated corpuscles, and, unless certain conditions are present, the latter are incapable of escape. A mathematical analysis then gives the very simple result that if the radiation emanating from the spherical surface in the plane of its magnetic equator and subjected only to the magnetic influence of the sphere, exceeds a distance greater than 2·414 times the radius, this radiation can never return to the sphere, but is directed towards infinity. This result is independent of the magnetic moment of the sphere and the magnetic rigidity of the corpuscular rays. Some exhaustive researches upon magnetic storms and polar aurora have shown that precipitations of helio-kathodic rays exist in the maximum belt of the aurora. A discussion of Schuster's work on this question then follows. The author has performed experiments with a magnetic globe which have verified the above theoretical treatment. From the experiments came the conception that there are currents circulating round the sun at a relatively small distance outside, which play a very prominent part in solar magnetism and constitute its primary cause. The movements of sun-spots also appear to require for their explanation that solar magnetism may vary periodically, with a minimum in the year of minimum spots. H. H. Ho.

1936. *Photographs of the Aurora Spectrum.* **L. Vegard.** (Phys. Zeitschr. 14. pp. 677–681, Aug. 1, 1913.)—According to Störmer's calculations, the daily variation of the aurora polaris may be used to determine the deflectibility of the solar discharges giving rise to it. The author prefers to draw conclusions from the structure and the spectrum of the aurora [Abstract No. 868 (1912)]. The structural evidence favours an α-rays cause. Spectrum photographs were obtained at Bossekop, Finmarken, in the course of the three months ending the year, 1912, with sufficient dispersion to reduce the error of the brighter lines to half an Ångström unit. The three strongest lines thus measured are at 4708·0, 4278·0, and 3914·6. Fainter lines are at 5571·3, 4646·8, 4234·2, and 4200·3. All the lines except the greenish-yellow 5571·3 correspond to heads of nitrogen bands as produced by the impact of α-rays. The line 5571·3 is near the strong argon line 5572·6. The results favour the view that the aurora is produced by the impact of solar α-particles upon nitrogen molecules. E. E. F.

1937. *Radial Velocities of Vapours in Sun-spots.* **C. St. John.** (Comptes Rendus, 157. pp. 428–430, Sept. 1, 1913.)—The investigation of the radial motion of sun-spot vapours, tangential to the solar surface, first announced by Evershed in 1909, has been continued with the tower telescope at Mount Wilson; and several striking results are summarised. (1) The displacements are proportional to wave-lengths, showing the phenomenon to be a motion effect. (2) If the lines of iron are grouped in order of their intensity in the Fraunhofer spectrum, the displacements appear to be decidedly in the opposite relation, *i.e.* the *weaker* lines have the *greater* displacements. The sign of the displacement is positive, indicating a movement of the vapour from the centre to the outer boundary of the spot. The strongest lines appear to have very little displacement. (3) These differences are interpreted as indicating a vertical distribution of the vapours producing the lines of different intensity. (4) The resulting distribution is such that H_3 and K_3 of calcium are emitted at a higher level than H_α of hydrogen, and that H_α is between the levels of K_3 and K_2. This is in accordance with the conclusions published by Deslandres from a study of spectroheliograms taken at Meudon. C. P. B.

LIGHT.

1938. *New Types of Spectrophotometer on the "Flicker" Principle.* **J. R. Milne.** (Roy. Soc. Edinburgh, Proc. 33. pp. 257–263, 1912–1913.)—In a previous paper [Optical Convention, Proc. p. 178, 1905] the author described a new form of spectrophotometer in which the comparison of relative brightness is affected by bringing the two beams accurately edge to edge. The present paper describes some spectrophotometers in which the comparison is effected by allowing the two beams to fall alternately on the eye in rapid succession. The best method of obtaining an intense beam of parallel rays, having each ray of equal brightness, is first discussed, as the production of such a beam is very necessary in all spectrophotometric measurements of light absorption. Next there are briefly described three new types of "flicker" spectrophotometer, the first of these depending on polarisation, the second on refraction, and the third on reflection. All three are quite successful: the choice of the best to use depends on the circumstances of the case. Finally, three general governing principles are laid down which would seem to apply equally to all types of flicker photometer. A. W.

1939. *Double Refraction of Optical Glass.* **E. Zschimmer** and **H. Schulz.** (Ann. d. Physik, 42. 2. pp. 345–396, Sept. 23, 1913.)—A description of the apparatus used in this research has previously been given [see Abstracts Nos. 388 and 1807 (1913)]. The research deals with the dependence of the double refraction of optical glass on its chemical composition and on its shape. The way in which strain depends on the temperatures of the cooling process is dealt with at length. It was found by extrapolation that a glass containing about 76 % PbO should have the property of exhibiting no double refraction, whatever the cooling process, for light of wave-length λ5461. The PbO-content of a glass found by Pockels to show no double refraction for any deformation was 75·7 %. A. W.

1940. *Refraction of Gases at Different Temperatures and Pressures.* **H. D Ayres.** (Phys. Rev. 2. Ser. 2. pp. 161–182, Sept., 1913.)—An interference method was used in the experiments, and the change ensuing in the optical path of light traversing twice the distance between two reflecting surfaces upon admitting a gas to the space between the surfaces, was determined. If k is the total shift of interference bands of wave-length λ, n the index of refraction of the gas, and d the distance between the surfaces, then $n-1=k\lambda/2d$. The gases dealt with were air, nitrogen, oxygen, hydrogen, and CO_2. Observations were made about 0° C. and at temperatures ranging down to that of liquid air. The results are tabulated and graphed. From the various curves it is seen that within the limits of accuracy of observations of experiments, the relation between the indices of refraction and the pressure is a linear one except for the case of CO_2 at 0° and for nitrogen at liquid-air temperature. In other words, the relation between the refractive indices and the density as computed by Boyle's law is a linear one. For the CO_2 at 0° C. and the nitrogen at liquid-air temperature the densities have been computed by means of van der Waals' equation. Using the value of the constants a and b obtained from the critical pressure and temperature of the respective gases, the relation between the resulting densities and refractive indices was found to be very accurately a straight line. A table is also given showing the variation of the refractive indices with the densities as obtained by the two methods, and also comparing the formula of Gladstone and Dale with the Lorentz-Lorenz formula. It may be noted that for nitrogen at 0° C. (excluding the two lowest pressures), computing the densities by Boyle's law and using the Gladstone and Dale expression, the values of the constant vary only about 0·2 %. A. W.

1941. *Gouy-Sommerfeld's Diffraction.* **A. Kalaschnikow.** (Jurn. Russk. Fisik.-Chimičesk. Obščestva, 44. 3. pp. 137–144, 1912.)—Demonstrates that by photographic means, diffraction at a greatly bent angle is easy to observe. The author's experimental results are in agreement with Sommerfeld's theory. I. P.

1942. *Passage of Waves through Fine Slits in Thin Opaque Screens.* **Rayleigh.** (Roy. Soc., Proc. Ser. A. 89. pp. 194–219, Aug. 27, 1913.)—In a former paper (Phil. Mag. 43. p. 259, 1897; Scientific Papers, vol. 4, p. 283) the author gave solutions applicable to the passage of light through narrow slits in infinitely thin perfectly opaque screens, for the two principal cases where the polarisation is either parallel or perpendicular to the length of the slit. It appeared that if the width (2b) of the slit is very small in comparison with the wave-length (λ), there is a much more free passage when the electric vector is perpendicular to the slit than when it is parallel to the slit, so that unpolarised light incident upon the screen will, after passage, appear polarised in the former manner. This conclusion is in accordance with the observations of Fizeau (in 1861) upon the very narrowest slits. Fizeau found, however, that somewhat wider slits (scratches upon silvered glass) gave the opposite polarisation; hence the present author wished to extend the calculation to slits of width comparable to λ. The subject has also a practical interest in connection with observations upon the Zeeman-effect.

Elliptic co-ordinates not offering a solution, though apparently appropriate to such a problem, the author again uses the approximate methods of the former paper. The result of the theory is that for very narrow slits the light with electric vector perpendicular to the slit is favoured, for slits of a certain critical width the two polarisations are equally treated, and finally, for wider slits the light with electric vector parallel to the slit is favoured. Curves for the two polarisations are given and one crosses the other at the critical width of slit. If the incident light were white and the width of the slit about one-third the wave-length of yellow-green, there could be distinctly marked opposite polarisations at the ends of the spectrum. This is in good agreement with the estimates of Fizeau. These calculations do not apply to thick screens as in a spectroscope slit. E. H. B.

1943. *Double Mirage.* **W. Hillers.** (Abhandl. des Naturwiss. Vereines, Hamburg. Phys. Zeitschr. 14. pp. 718–719, and 719–723, Aug. 1, 1913. Abstract.)—Describes and reproduces photographs of a triple mirage effect obtained at a wall heated by the sun. One of the pictures is that of a boy

leaning against the wall at a distance of 162 m. from the camera, which was 16 cm. from the wall. The mirror image immediately adjoins the figure, and beyond it again is a direct image. The author works out a mathematical theory of the mirage on the lines of Vince, but without using elliptic integrals.
E. E. F.

1944. *Scattering of Light.* **J. R. Milne.** (Roy. Soc. Edinburgh, Proc. 33. pp. 264–281, 1912–1913.)—The present paper describes a number of experiments made in connection with Christiansen's experiment in which a beam of light is passed through a transparent insoluble powder immersed in a liquid, with the result that light of the particular colour for which the indices of powder and liquid are the same passes unaffected, while light of all other colours is scattered. In this paper only the simplest case of the above is dealt with, that, namely, in which a flat piece of glass, ground on one side, takes the place of the powder (the rugosities of the ground surface representing a single layer of grains), and air takes the place of the liquid. In such a case there is, of course, no colour of light for which the indices of solid and liquid are alike, and it was found that the colour of the light made very little difference to the results. But different ways of grinding the glass surface led to very different effects. Each specimen of glass employed was photomicrographed, and had its polar light-distribution measured by a photometer. Two methods of characterising the particular scattering power of a screen have been formally defined—the one connected with the "angle of max. total emission," and the other with the "equivalent cavity." The investigation will be continued on the above lines, also in the direction of ascertaining the effect of a number of plates, and in investigating the polarisation effects, which some rough preliminary experiments have shown to be marked.
A. W.

1945. *Pressure of Light by Use of Thin Foil.* **G. D. West.** (Phys. Soc., Proc. 25. pp. 324–330 ; Discussion, p. 330, Aug., 1913.)—The pressure of the radiation emitted by a carbon filament lamp at a distance of a few cm. is sufficient to cause a microscopically measurable deflection of the end of a suspended strip of gold or aluminium foil, and by this means the radiation-pressure can be calculated knowing the weight of the strip. The results agree to within about 10 per cent. with the energy density of radiation as measured by the initial rise of temperature of a copper plate exposed to the radiation.

The best results are obtained by working in an atmosphere of hydrogen, 1 cm. to 2 cm. pressure, but good results are obtained with hydrogen at atmospheric pressure. Air at 1 cm. to 2 cm. pressure also gives good results. The method involves no laborious adjustments, and the apparatus is not seriously affected by vibration.
E. H. B.

1946. *Absorption of Gases in Infra-red.* **E[va] v. Bahr.** (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 710–730, Aug. 30, 1913.)—The infra-red absorption bands of gases are discontinuous at low pressures. But the discontinuities are generally less marked as the pressure increases, so that the bands, when max. absorption is reached, appear to be almost continuous. Raising the temperature of CO has the effect of separating the two maxima of its absorption band from one another, at the same time causing a broadening of the band. The experimental results obtained up to the present are compared with Bjerrum's theory of infra-red absorption spectra and with various consequences of the theory. The agreement is in general satisfactory.
A. W.

1947. *New Band Spectrum associated with Helium.* **W. E. Curtis.** (Roy. Soc., Proc. Ser. A. 89. pp. 146–149, Aug. 19, 1918.)—In Fowler's recent observations of the principal series of hydrogen lines in the spectra of helium tubes traces were frequently seen of a band spectrum whose origin was unknown. With suitable precautions it was found possible to obtain the spectrum quite brightly, and further investigation showed that it may be attributed to He. An account of the spectrum has been given by Goldstein [Abstract No. 1488 (1918)], and is in close agreement with that here given. Photographs are reproduced and wave-length tables given, the bands extending from λ6899 to λ8118. A. W.

1948. *New Series of Lines in the Spark Spectrum of Magnesium.* **A. Fowler.** (Roy. Soc., Proc. Ser. A. 89. pp. 188–187, Aug. 19, 1918.)—A recent investigation suggested that the spectrum of hydrogen was unique in having two principal series of lines which are related to each other in the same manner as the sharp and diffuse series. In seeking for further examples of such series, analogy with hydrogen suggested spark spectra as the most promising sources. One of the most remarkable spark lines is the Mg line λ4481, which ordinarily is not visible at all in the arc, but is by far the strongest line in the spark. Further, there is a series of single lines in the arc spectrum of Mg, first identified by Rydberg, which it seemed might possibly be analogous to the Balmer series of hydrogen lines. But there were only two recorded lines which could possibly be connected in series with λ4481; namely, the lines given by Exner and Haschek at 8106·5 and 2659·5. Other associated ultra-violet lines, however, have now been photographed, and it results that the spark-lines form two series like those of hydrogen, λ4481 being analogous to the first principal line of hydrogen λ4686. The results are discussed. A. W.

1949. *Band Spectrum attributed to Carbon Monosulphide.* **L. C. Martin.** (Roy. Soc., Proc. Ser. A. 89. pp. 127–182, Aug. 19, 1918.)—The experiments described in the present paper were made in connection with the investigation of sulphur spectra developed by the nitrogen afterglow, in continuation of previous observations by Strutt and Fowler [see Abstracts Nos. 1889 (1911), 596, 1119, 1897 (1912)]. A result of considerable interest is the detection of a series of ultra-violet bands which appear to be characteristic of a compound of sulphur and carbon. This band system extends from λ2486 to λ2887 approximately. It is, however, quite distinct from that developed, in the same region, by CS_2 in the afterglow. Further photographs showed that the two sets of bands had nothing whatever in common. Confirmation of Strutt's work on the chemical actions taking place between CS_2 and the active nitrogen was obtained. A green deposit of nitrogen sulphide formed in the experimental tube, and also a brown one of polymerised carbon monosulphide, the latter only in the presence of a stray discharge. The new bands were observed by using a hollow carbon, well charged with sulphur, as the upper (positive) pole of the arc. In these circumstances a steady flow of melted sulphur into the arc was maintained. Like the sulphur bands, the new bands are degraded towards the less refrangible side. Experiments with a sulphur vacuum tube showed that the bands are not given by the discharge through pure sulphur vapour; also that they are only developed to any extent when the carbon line 2478 is present. They have nothing whatever to do with the ordinary spectra of carbon or nitrogen. Wave-length tables are given of the bands and photographs are reproduced. A. W.

1950. *Measurement of Intensity Distribution in Spectral Lines.* II. **P. P. Koch.** (Ann. d. Physik, 42. 1. pp. 1–29, Aug. 26, 1913.)—In a previous paper a photographic-photometric method was described by which the intensity distribution in spectral lines may be determined [Abstract No. 759 (1911)]. It appeared that the measurements of the intensity distribution depended to a certain extent on the apparatus employed and possibly on the source of light. The present paper deals with the question of eliminating the effect of the apparatus and the estimation of the true intensity distribution. [See also Abstract No. 1358 (1912).] A. W.

1951. *Reflection Spectra of Neodymium Compounds.* **P. Joye.** (Archives des Sciences, 36. pp. 41–58, July, and pp. 113–138, Aug., 1913.)—Photographs and measurements have been made of the reflection spectra of a number of neodymium compounds. These include the hydrate $Nd_2O_3, 3H_2O$, and the two hydrates, $2Nd_2O_3, 3H_2O$ and Nd_2O_3, H_2O, the existence of which has been ascertained; the oxide, sulphide, sulphate, chloride, bromide, carbonate, oxalate, and nitrate. The influence on the spectra of the presence of a foreign substance, of the temperature, and of the method of preparation of the salts has been investigated in certain cases. In general, the spectra are characterised by groups of lines for values of λ between 4200 and 4500, 5080 and 5480, and 5700 and 6000. Comparison of the spectra for the various hydrates shows that loss of water displaces the spectrum towards the red end. On the other hand, the introduction of acid radicals causes displacement towards the violet. The results are given in detail in the original paper.
T. H. P.

1952. *Wave-length Standards.* **C. Fabry** and **H. Buisson.** (Journ. de Physique, 8. Ser. 5. pp. 613–622, Aug., 1913.)—The exactitude of secondary international standards is first discussed. It is seen that many researches lead to the conclusion that the values given by interference methods are perfectly correct and identical with those found by means of a grating. The paper then deals in succession with (i) The progress of measurements of secondary standards. (ii) Variability of wave-lengths. (iii) Tertiary standards of wave-length. (iv) The utility of having more numerous secondary standards measured by interference methods. A brief summary cannot be given.
A. W.

1953. *Critical Study of Spectral Series.* III. **W. M. Hicks.** (Roy. Soc., Phil. Trans. 213. pp. 323–420, Oct. 22, 1913. Roy. Soc., Proc. Ser. A. 89. pp. 125–127, Aug. 19, 1913. Abstract.)—A continuation of previous work [see Abstract No. 1364 (1912]. The present paper deals with the atomic weight term and its import in the constitution of spectra. The wave numbers of the lines in a spectrum which form any of the recognised series can be calculated, as is well known, from an expression of the form $n = N/D_1^2 - N/D_m^2$, where $N = 109675$ and $D_m = m +$ fraction, the fraction being in general a function of the integer m. The constant doublet or triplet separations of sharp (S) and diffuse (D) series are formed by the deduction of a quantity Δ, or Δ_1, Δ_2 in the case of triplets, from D_1, and it has long been known that these quantities are very roughly proportional to the squares of the atomic weights when elements in the same group are compared. It is shown that there is a definite quantity in connection with each element which is of fundamental importance in the building up of its spectrum. It is proportional to the square of the atomic weight: in fact, if w denote the atomic weight divided by 100, its value is $(90{\cdot}4725 \pm 0{\cdot}0013)w^2$. This quantity is of such universal application that it is useful to have a special name for it, and it has been called the *oun* (ων). Its value is denoted by δ_1, but δ is used for the multiple $4\delta_1$, as it is of very frequent occurrence. The evidence for its existence is based on the arc spectra of He, the elements of groups I and II, the Al sub-group and Sc of III, and the O, S, Se of VI of the periodic table—in other words, all those elements in which the series lines have been allocated. It is found :—(i) That the Δ which give the doublet and triplet separations are all multiples of their respective *ouns.* (ii) That the corresponding quantities, which give the satellite separations in the D series, are also multiples of the *oun.* (iii) That the F series show the satellites depending in a similar way on the *oun.* (iv) That, in a large number of cases, lines are related in such a way that the differences of their denominators are multiples of the *oun*, and that frequently in place of an expected line which is not observed another occurs related to it in this manner : it is said to be collaterally displaced. After reviewing the evidence for the existence of the *oun* the paper deals in succession with :—(*a*) *The Constitution of the D Series.*—After establishing the dependence of the satellite separations on the *oun* it is shown to be possible that the D series may not depend directly on a formula involving m, but that the D_m of different orders may be given by the successive addition, or subtraction, of various multiples of the *oun.* It is curious that where there are no satellites these differences are multiples of the Δ themselves. Evidence is also given to show that the decimal part of D (2), *i.e.* for the first line, is a multiple of Δ, or Δ_2 for triplets, but that, in the case where satellites exist, the extreme satellite is to be taken. (*b*) *The Constitution of the F Series.*—The F series is one whose limit is the variable part in the formula for the D series corresponding to the first of the D lines ; in other words, it depends on the D series in the same way that the limits for the S and D series depend on the first line of the P series. For all elements, except the alkaline earths, the lines are far in the ultra-red, and it is only recently that waves of extreme wave-lengths have been measured by Paschen. It is probable that the VF for the first lines in each sub-group may be the same, and even possible that it may be the same in all, the earths excepted. In the earths there is a very large number of strong well-defined lines which are connected collaterally with one another, or with the lines of the series themselves, the displacements proceeding by multiples of Δ. These afford values of large multiples of Δ, and hence of δ ; and, in consequence, give very exact values for the latter. (*c*) The preceding results are then discussed with a view to obtaining a better approximation to the value of the *oun* as a function of w^2, on the supposition that it is always proportional to it. A value is obtained (see above) which is probably correct to a few units in the fifth significant figure. With further knowledge it is probable that this degree of accuracy may be extended to the sixth, and even beyond. It is clear that with such a knowledge of this constant, and with more definite and certain knowledge of spectral relations enabling values of δ of the same degree of accuracy to be obtained, it will be possible to determine atomic weights with extreme accuracy : an accuracy much beyond that attainable by methods depending on weighing. The large atomic weight of Ag, combined with the fact that it may be regarded as the basis of other atomic weights, would point to it as the best single element from which to deduce the value of δ/w^2. The value of its doublet separation can be determined with extreme accuracy, to one or two units in the sixth significant figure. But, unfortunately, the deduction of Δ from this is subject to an uncertainty which quite upsets that degree of accuracy. The most probable value is, however, very close to that obtained by the final discussion.

The uncertainty is due to a doubt as to the real relations of lines usually assigned to the S, D, and P series of Ag, and it is hoped to clear this up by a further consideration of the spectrum. It is then shown how the laws indicated in the foregoing discussion enable the doublet and the satellite differences for Au, and the limits of the series to be determined. The value of Δ for Se is considered in Appendix I. In Appendix II the wave-lengths of the lines of the D and F series treated of, together with short historical notes, are given. A. W.

1954. *Absorption Spectrum of Water-vapour.* **E[va] v. Bahr.** (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 731–737, Aug. 30, 1913.)—Further measurements of the absorption bands of water-vapour observed by Paschen at 5·9 and 6·5 μ lead to the conclusion that they probably constitute a Bjerrum double band. It further appears that both parts of this band are made up of a great number of narrow bands. The rotation frequency of the molecule as calculated from these narrow bands is in good agreement with the values found by Rubens in the residual ray region. A. W.

1955. *Additional Triplets and other Series Lines in the Spectrum of Magnesium.* **A. Fowler** and **W. H. Reynolds.** (Roy. Soc., Proc. Ser. A. 89. pp. 137–145, Aug. 19, 1913.)—Eight additional triplets have been measured in the spectrum of the magnesium arc *in vacuo,* six of which belong to the Diffuse and two to the Sharp series. For some of the previously known lines improved wave-lengths have also been obtained. Four additional members of the Rydberg series of single lines have also been photographed. Even a four-constant formula does not accurately represent this series. Four strong solar lines of previously unknown origin have been identified with lines of the Rydberg series, namely, 4167·44, 4057·67, 3986·90, 3938·55. A previously unrecorded line at 4354·53 may be united in a series with the known lines 5711·31 and 4730·21, having the same limit as the Rydberg series. This series is probably of the Sharp or second subordinate type. A. W.

1956. *Constitution of Mercury Green Line.* **F. F. S. Bryson** and **J. Logie.** (Phil. Mag. 26. pp. 866–875, Aug., 1913.)—From the investigations here dealt with it appears that the discrepancies in the positions of the satellites of the Hg green line as determined by different observers are for the most part apparent, not real, and are dependent upon the difficulty of judging the centre of the main wide line. A comparison table and diagrams are given, showing the positions and relative intensities of the satellites as determined by different observers. The discrepancies in the relative brightnesses in the different cases appear not to be due to any variations of temperature or of vapour pressure, and as they cannot well be attributed to absorption they remain at present unexplained. Experiments were undertaken with a view to studying the change of pattern observed by Janicki and by Galitzin and Wilip. The tubes used were exhausted by a Fleuss pump, and were in open connection with a P_2O_5 drying tube. On heating the tube slightly the effect was soon obtained. The discharge in the tube became very brilliant and very broad and continuous, suggesting a breakdown of the insulating properties of the vacuum, while the appearance in the echelon exactly corresponded to Janicki's description of "five equidistant bands." The temperature at which the effect is obtained varies from 200° C. to 260° C. or more, depending apparently upon the degree of vacuum. The effect, however, cannot be due solely to temperature, for in the earlier experiments the temperatures attained by the arc varied from 180° C. to over 400° C., and with this arc the effect could not be observed. The effect is more easily obtained with an imperfectly exhausted tube, though it could always be obtained with the highest vacua obtainable with the pump employed. The nature of the discharge seems to have some slight effect. When the hammer of the coil was working unsteadily the appearance would flicker in and out even at temperatures below 200° C., while when the proper conditions had been attained it worked smoothly. Measurements from photographs of the effect and the general appearance of the tubes when the effect is in evidence indicate that the effect is due to absorption, and is caused primarily by foreign vapours in the tube either left behind in exhausting, or obtained from the Al electrodes or the P_2O_5 tube; temperature and discharge being secondary factors. A. W.

1957. *Emission of "Rest" Series Lines by Canal Rays.* **J. Stark.** (Ann. d. Physik, 42. 1. pp. 163–180, Aug. 26, 1913.)—From observations on the canal rays of various elements the author concludes that—(*a*) The "rest" series lines are produced by a canal-ray particle piercing the outer layers and at the same time ionising a motionless atom. (*b*) The ratio of the intensity of complex "rest" lines to simple "rest" lines increases with the velocity of the canal rays. (*c*) Helium canal rays are favourable to the production of simple "rest" lines in another element. (*d*) Probably when a heavy canal-ray particle strikes an Al-atom it imparts light-energy and motion to it. (*e*) Canal-ray particles of heavy elements allow He-atoms to go through them without altering their velocity appreciably. J. M.

1958. *Anomalous Zeeman-effect in the Satellites of Mercury Lines.* **H. Nagaoka and T. Takamine.** (Nature, 91. pp. 660–661, Aug. 28, 1913.)—Owing to the extreme complexity in the distribution of lines when the field strength is increased, there have been up to now no continuous observations indicating the position of satellites of mercury lines in different magnetic fields, though several workers have shown that the satellites of some Hg lines are separated in a regular manner in weak fields, and Gmelin has found a satellite of the yellow line having anomalous character. Measurements have been made by the authors of the present paper on the satellites of the violet line λ4047 and the green line λ5461, in fields ranging up to 30,000 gauss, and it has been found that the satellites show anomalous Zeeman-effect, either as regards intensity or the mode of separation, and in nearly all cases both combined. An echelon grating was employed, sometimes crossed with a Fabry-Perot air plate or a Lummer-Gehrcke plane-parallel plate to eliminate the false lines. From a large number of photographs of the transverse effects obtained in different fields, which were mostly uniform but sometimes heterogeneous, the positions of the satellites were plotted and traced into continuous curves, which are reproduced, different diagrams showing the components vibrating parallel and perpendicular to the field respectively. It is seen that for parallel components the separation is not generally proportional to the magnetic field. The satellites of λ4047 are characterised by approaching the central principal line asymptotically, while in weak fields the change in wave-length is quite rapid. The satellite at − 60 m.Å.U. from the principal line is remarkable in possessing a branch towards the positive side approximately a parabola with vertical axis, and one towards the negative side a similar curve with horizontal axis; hence the change wrought by the magnetic field is proportional to $\sqrt{H}$ for the former branch and to H^2 for the latter. Other satellites have similar peculiarities, which are discussed.

The different branches into which the satellites are divided ultimately run parallel to the principal lines, whether the vibration takes place parallel or perpendicular to the direction of the field. It is in the transition from zero field to this final stage that the separation of the satellites takes place in a singularly anomalous manner, which is seldom met with in the separation of the principal lines. This fact will have an important bearing on the elucidation of the nature of the satellite, and probably may have an intimate connection with the recent experiments of Paschen and Back.

The investigation is being continued with satellites of the lines of other elements. A. W.

1959. *Reflection of Canal Rays.* **J. Stark.** (Ann. d. Physik, 42. 1. pp. 231–237, Aug. 26, 1913.)—A note on E. Wagner's communication [Abstract No. 1474 (1913)]. The author's own experimental methods are defended and some additional observations given. [See Abstract No. 1085 (1909).] J. M.

1960. *Lines of Aluminium, Argon and Mercury in Canal Rays due to Singly- and Multiply-charged Ions.* **J. Stark, G. Wendt, H. Kirschbaum** and **R. Künzer.** (Ann. d. Physik, 42. 2. pp. 241–302, Sept. 23, 1913.)—A continuation of previous work [see Abstracts Nos. 982 and 1283 (1913)]. The researches dealt with show (i) aluminium may in the canal rays have singly- doubly-, or trebly-charged positive atomions, with three corresponding velocity intervals. With a kathode-fall of less than about 8000 volts, the singly- and doubly-charged Al-ions exceed in number the trebly-charged ions in the canal-ray bundle behind the kathode; if the kathode-fall exceeds 8000 volts the trebly-charged ions are found in much greater numbers. The differently charged ions are the carriers for different line spectra. To the spectrum of the singly-charged Al-ions belongs the doublet λ3961·7, 3944·2; to the spectrum of the doubly-charged ions the line λ4663·5; and to the trebly-charged ions belong the lines λ4529·7, λ4513·0 and λ4480·0. (ii) Similarly it is found that argon shows the existence of singly-, doubly-, and trebly-charged ions. The lines of the red Ar-spectrum have for carriers positive singly-charged Ar-atomions. The lines of the blue Ar-spectrum in the visible region have for the greater part positive doubly-charged atomions, for the lesser part positive trebly-charged atomions as carriers. In the emission of the displaced line in the Ar canal-ray Doppler-effect, whether the rays pass into Ar or into He, there exists a variable state of equilibrium between the three kinds of ions. Slow kathode rays give rise to the emission of a preponderance of singly-charged Ar-lines, while quickly-moving kathode rays give rise more to doubly- and trebly-charged lines. (iii) Mercury exhibits ions with as many as four atomic charges. The carriers of the Hg doublet λ2847, 2224 are the positive singly-charged Hg-atomions; the carriers of the first and second subordinate series of triplets are the positive doubly-charged ions. The lines λ4916, 4339, 4347, 4109, 4078, have the positive trebly-charged ions; the intense lines appearing in the negative glow λ4797, 4707, 4486, 4398, have the positive quadruply-charged ions as carriers. The line λ2536·7, probably the first member of a series of simple lines, has probably the neutral Hg-atom as carrier. Hg-canal rays in H or He show, for a kathode-fall of less than 8000 volts, a preponderance of singly- and doubly-charged rays, and only a very small proportion of trebly-charged rays. With a kathode-fall of 15,000 volts and upwards, there appear, besides the singly- and doubly-charged rays, a considerable number of trebly- and also of quadruply-charged rays. Between the neutral Hg canal-rays, the singly-, doubly-, trebly-, and quadruply-charged rays, there exists, under the conditions giving rise to the emission of the displaced line, a variable state of equilibrium. A. W.

1961. *Frequency of X-rays.* **W. Seitz.** (Phys. Zeitschr. 14. pp. 659–660, July 15, 1913.)—A criticism of Zemplén's evaluation of energy quantum of Röntgen rays [Abstract No. 1298 (1913)]. The efficiency of the conversion of kathode-ray into X-ray energy is much higher than 0·001, since most of the X-rays are soft, and are absorbed by the glass or by the antikathode itself. It is quite possible that the energy of the X-rays is consistent with the value assigned by the quanta theory. E. E. F.

1962. *Structure of X-radiation.* **W. F. D. Chambers and I. G. Rankin.** (Nature, 91. p. 686, Aug. 21, 1913.)—Following up the work previously recorded [see Abstract No. 1291 (1913)] the authors have now obtained results which point to the conclusion that some part of these effects at least must be referred to the structure of the primary beam. In an early trial arranged to study the disposition of the spots from a thin lamina of mica, normal to the beam and covering a ¼-in. aperture, the spots were not present, but instead the photographic plate, exposed at a distance of 50 cm., was entirely covered by dark parallel bands about ½ cm. wide and normal to a sharply defined bright cross. In later experiments without mica, and using cast-iron and other screens, both with and without apertures, a system of crossed bands appeared. The same phenomena appeared even when no other obstacle than a thick sheet of plate glass was interposed. E. H. B.

1963. *Effect of Thermal Movements on the Interference Phenomena of Röntgen Rays.* **P. Debye.** (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 678–689, Aug. 15, 1913.)—A mathematical inquiry as to the effects, if any, of the thermal movement on the phenomena in question, from which the author concludes as follows :—(1) The thermal movements have no influence on the sharpness of the interference maxima. (2) Their influence on the intensity hindered the discovery of radiation with a wave-length $< 10^{-9}$ cm. [See next Abstract.] E. H. B.

1964. *Röntgen-ray Interference.* **P. Debye.** (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 738–752, Aug. 30, 1913.)—A mathematical discussion of the distribution of intensity in the interference bands from Röntgen rays. The interference bands of a regular crystalline grating are first treated with special regard to the thermal movements ; the effect of temperature is afterwards inquired into. The low-temperature work on the specific heat of diamond and the quantum hypothesis are also referred to. [See preceding Abstract and No. 1153 (1913).] E. H. B.

1965. *Transmission of X-rays through Metals.* **H. B. Keene.** (Nature, 91. p. 607, Aug. 14, 1913.)—A parallel narrow beam of X-rays was allowed to pass normally through three rolled metal sheets and fall on a photographic plate placed behind and parallel to the sheet. The patterns obtained were found to fall into two classes : (*a*) in which the central spot produced by the direct beam is surrounded by an irregular halo of smaller spots ; and (*b*), in which the central spot is surrounded by faint extended patches forming a perfectly symmetrical pattern. The design varies with the metal. Class (*a*) markings are given by metal sheets which are either well aged or recently annealed, while the symmetrical patterns of class (*b*) are only obtained with newly-rolled sheets. The spots of the former are due to reflections from the microcrystals within the metal, while the symmetrical patterns of the latter are produced by the structure imparted to the metal in passing through the rolls. These star-like patterns are evidently analogous to those obtained when a beam of light passes through a crystal which appears streaky to the naked eye. By annealing a newly-rolled sheet the pattern changes from class (*b*) to class (*a*), and *vice versa*. E. M.

1966. *Range and Ionisation of the α-Particle in Simple Gases.* **T. S. Taylor.** (Phil. Mag. 26. pp. 402–410, Sept., 1913.)—The ranges were determined by observing the distance from the source at which scintillations were no longer produced. The results are as follows :—

	Range at 760 mm. and 0° C.		760 mm. and 15° C.		Ratio of Ranges.
	Polonium.	Radium C.	Polonium.	Radium C.	
Air	3·57 cm.	6·57 cm.	3·77 cm.	6·93 cm.	1·84
O_2	3·25	5·94	3·43	6·26	1·83
H_2	15·95	29·36	16·83	30·93	1·84
He	16·70	30·84	17·62	32·54	1·84

Experiments were also made on the rate at which the number of α-particles from RaC diminishes towards the end of the "range," the pressure of the gas being adjusted so that the range was the same in each case. The results show that for H_2 and He the beam of α-particles remains much more nearly homogeneous than for O_2 or air. This result would be expected from the theory of scattering. The Bragg ionisation curves were also obtained in the various gases, and it is shown that the He curve has the most pronounced "peak," and this peak occurs a little nearer to the end of the range. The theoretical curve $I = c/(r-x)^{1/3}$ (where r is the average range of the α-particles, x the distance from the source, and c a constant) is found to agree better for He and H_2 than for air. By integration of the ionisation curves it is shown that the ratio of the total ionisation in helium to that in either air or hydrogen is 1·05. E. M.

1967. *Notes on β- and γ-Rays.* **J. A. Gray.** (Phil. Mag. 26. 540–544, Sept., 1913.)—The paper deals with some effects of scattering on absorption curves of β- and γ-rays, and also on the comparison of the intensities of γ-rays which differ in penetrating power. In many cases, when taking absorption curves, it is found that the ionisation produced by the rays can be approximately expressed by the relation $I = I_0 e^{-\mu x}$, where I represents the ionisation and x the thickness of the absorbing material. It might appear at first sight that rays which were such that their quality was unchanged when they passed through matter would give such an ionisation curve. The author shows from a consideration of Schmidt's theory of absorption of β-rays [Abstract No. 1331 (1907)] that this is not necessarily the case. E. M.

HEAT.

1968. *Atomic Specific Heats between the Boiling-points of Liquid Nitrogen and Hydrogen. I. Mean Atomic Specific Heats at 50° Abs. of the Elements a Periodic Function of the Atomic Weights.* **J. Dewar.** (Roy. Soc., Proc. Ser. A. 89. pp. 158–169, Aug. 27, 1913.)—The specific heats of 58 elements have been determined between the temperatures of boiling nitrogen and boiling hydrogen. The substances were cut into pieces of uniform shape and cooled in a jacket containing liquid nitrogen; they were then allowed to drop into a calorimeter containing liquid hydrogen, and the volume of hydrogen gas evolved was measured. The corrections necessary to be applied in the calculation of the specific heat are detailed. It is shown that the specific heat is a periodic function of the atomic weight, and that the atomic heat curve has a similar form to the Lothar Meyer atomic volume curve. T. S. P.

1969. *Emissivity of Oxidised Metallic Surfaces.* **C. P. Randolph** and **M. J. Overholser.** (Phys. Rev. 2. Ser. 2. pp. 144–152, Aug., 1913.)—An experimental research reaching the following conclusions:—(1) The emissivity of an oxidised metallic surface depends on the depth of the surface oxidation. It is accordingly a function of (*a*) the temperature to which the surface has been heated, and (*b*) the time the surface has been maintained at that temperature. (2) The emissivities of certain surfaces were found as given in the table for oxidations at about 600° C. and maintained until the emissivities were constant.

Surfaces.	Temperatures.		
	200° C.	400° C.	600° C.
Silver	0·020	0·030	0·038
Oxidised zinc	—	0·110	—
Oxidised aluminium	0·113	0·153	0·192
Oxidised nickel	0·369	0·424	0·478
Oxidised copper	0·568	0·568	0·568
Oxidised brass	0·610	0·600	0·589
Oxidised lead	0·631	—	—
Oxidised cast-iron	0·643	0·710	0·777
Oxidised steel	0·790	0·788	0·787
Black body	1·000	1·000	1·000

E. H. B.

1970. *Thermal Effects produced by Heating and Cooling Palladium in Hydrogen.* **J. H. Andrew** and **A. Holt.** (Roy. Soc., Proc. Ser. A. 89. pp. 170–186, Aug. 27, 1913.)—The authors have plotted the cooling and heating curves of palladium of various kinds in vacuum and in hydrogen. It is shown that Pd is probably dimorphic, the stability of the two forms depending on the temperature. The rate of change of the one form into the other is extremely slow. The initial rapid occlusion of hydrogen is probably due to the presence of the amorphous form of Pd, and in the absence of such an amorphous film Pd may be quite passive with regard to the occlusion of gas in the cold. It is probable, however, that the passivity is apparent rather than real, and that if sufficient time were allowed for occlusion to take place a volume of gas equal to that occluded by active Pd would pass into solution. At temperatures above 100° a rapid occlusion of a small quantity of hydrogen occurs with both forms of Pd, a constant quantity of heat being developed. Both varieties of Pd cease to absorb hydrogen above a certain temperature, and above 150° they both have an equal affinity for the gas. T. S. P.

1971. *Porous Plug Method for Mechanical Equivalent of Heat.* **J. R. Roebuck.** (Phys. Rev. 2. Ser. 2. pp. 79–94, Aug., 1913.)—A method of measuring the mechanical equivalent of heat by observations of the change of pressure and temperature when water is forced through a porous plug is fully described. Ordinarily the method would be complicated by a temperature-change caused by the readjustment of internal kinetic and potential energies with change of volume, and an adiabatic free expansion experiment would be necessary to determine it. However, with water, experiments to be published later show that by suitably choosing the working temperature (3·59° C.) and the initial and final pressures (34 kg./cm.^{2} and 1 kg./cm.^{2}) no change of temperature occurs in free adiabatic expansion, so that the only temperature-change in the porous plug experiment under these conditions arises from the external work done. The pressure change was read by a mercury-in-glass open tube manometer, and the temperature-rise, amounting to 0·76 deg. C., by means of two high-resistance Pt thermometers. The mean value of the mechanical equivalent obtained, 4·2087, agrees well with that obtained by Barnes, 4·2078, for this temperature. F. J. H.

1972. *Temperature Radiation of CO_2.* **H. Schmidt.** (Ann. d. Physik, 42. 2. pp. 415–459, Sept. 23, 1913.)—Taking special precautions to ensure an homogeneous temperature in the gas mass, the author finds that:—(1) CO_2 shows the emission and absorption bands already observed by Paschen, proving that the temperature radiation of gases may be discontinuous. (2) With constant pressure the absorption increases with the temperature, but more rapidly on that side of the band corresponding to the longer wave-lengths. (3) Very probably Kirschhoff's law holds for the radiation of an evenly-heated mass of CO_2. J. M.

1973. *Effect of Pressure on the Absorption of Long-wave Radiation in Gases.* **E[va] v. Bahr.** (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 673–677, Aug. 15, 1913.)—In this research the relation of the pressure and absorption of waves from 100 to 350 μ in HCl, SO_2, and H_2S was investigated. The absorption curves show a form similar to those obtained earlier for shorter waves. For pressures above 200 mm. the increase of absorption with pressure is almost linear. But for smaller pressures the absorption curves fell down more steeply, especially in the case of SO_2. [See Abstracts Nos. 1772 (1910) and 1480 (1911).] E. H. B.

1974. *Convection and Radiation of Heat.* **I. Langmuir.** (Amer. Electrochem. Soc., Trans. 23. pp. 299–330; Discussion, pp. 330–332, 1913.)—The paper is an extension of the author's earlier work [see Abstracts Nos. 337 and

827B (1912)] to cover convection of heat from plane surfaces. The author first develops formulæ for the loss of heat by free convection for plane surfaces, horizontal cylinders, and spheres, on the assumption that such convection really consists in conduction through a film of gas of definite thickness. On this theory, if the value of the film thickness is known for a plane surface, it can readily be calculated for the others, and by the use of a formula given in a previous paper for the dependence of the conductivity of gases upon temperature, the quantity of heat lost by convection can be calculated for any temperature. Experiments are described in which the heat lost from plane surfaces at various temperatures is determined. This includes heat lost both by convection and radiation, but by using silver as the standard substance, and calculating the small amount of heat lost from it through radiation by means of Hagen and Rubens' formula combined with Wien's displacement law, the amount lost by convection from the various surfaces is determined. The value of the film thickness for a vertical plane surface calculated from this is independent of the temperature above 400° C., and agrees very closely with that obtained from experiments with small wires; at low temperatures, however, a greater film thickness is required. The laws of Dulong and Petit and of Lorenz are shown to hold very satisfactorily even up to high temperatures, giving better results than the film theory for low temperatures, but they do not enable the effect of size and shape to be taken into account. From horizontal surfaces the convection from the upper surface is 10 % greater, and from the lower 50 % smaller, than from the vertical surface. By applying the values for the convection loss from silver to the results with other substances, the amounts of heat radiated, and consequently the emissivities, are determined. Curves are given which show the variation with temperature of the total amount of heat lost from the various surfaces. The film theory is found not to apply to convection forced by air currents, but Russell's formula [see Abstract No. 108 (1911)] agrees well with experimental data. F. J. H.

1975. *Monatomic Gases and the Quanta Theory.* **W. H. Keesom.** (Phys. Zeitschr. 14. pp. 665–670, Aug. 1, 1913.)—An attempt to apply Debye's method of calculating specific heats to an ideal monatomic gas instead of a solid. The attempt in this direction made by Tetrode [Abstract No. 1018 (1913)] only leads to results in agreement with the equation of condition of helium if the "temperature energy" per frequency is increased by a "zero energy" having the amount $\frac{1}{2} h\nu$, as already attributed by Einstein and Stern to the rotation of H_2 molecules. Helium has at normal densities a zero-point pressure of $\frac{1}{2}$ mm. The author assumes that the spectrum of a gas can be indicated by Debye's method for solids. He shows that the pressure is always greater than the equipartition pressure $p = RT/v$, especially at low temperatures. Nernst's heat theorem applies also to an ideal gas. The author deals with pressure and specific heat on these lines. E. E. F.

1976. *Free Electrons in Metals.* **W. H. Keesom.** (Phys. Zeitschr. 14. pp. 670–675, Aug. 1, 1913.)—Applies the results of the preceding paper to an "ideal gas" consisting of electrons in the interior of a metal. At low temperatures the number of free electrons per unit volume approaches a constant finite value, and so does the mean speed, thus agreeing with W. Wien's theory of electric conduction [Abstract No. 658 (1913)]. For high temperatures the theories of Riecke, Drude, and Lorentz are approached. Two difficulties hitherto confronting the equipartition theory are eliminated, one being the high conductivity found by Onnes at the lowest temperatures, and the other difficulty that offered by the small contribution of free electrons to specific heat, especially in the theory of the Thomson-effect. It becomes possible to assign definite density values to the electrons at a given temperature. The author deals with thermoelectric force and the Thomson-effect along these lines. E. E. F.

1977. *Vapour Pressure and Entropy of Monatomic Substances.* **O. Stern.** (Phys. Zeitschr. 14. pp. 629–632, July 15, 1913.)—The absolute value of the vapour pressure of a solid substance can be calculated by the quanta theory, which gives the entropy constants of the gas and the solid. A second method is by the interpretation of vaporisation by molecular theory. The author calculates the vapour-pressure formula for a monatomic solid possessing the Dulong-Petit specific heat (1) thermodynamically, with the aid of the quanta theory; (2) kinetically, with the aid of Boltzmann's "*e*-theorem." The vapour is taken to be an ideal gas, the solid as consisting of identical monochromatic resonators. Both methods give the same formula for the vapour pressure at high temperatures, viz.—

$$p = (2\pi)^{3/2} \frac{m^{3/2} \nu^3}{k^{1/2}} \frac{1}{T^{1/2}} e^{-\lambda_0/RT},$$

where $k = R/N$ and ν is the frequency of the resonators. E. E. F.

1978. *Partition of Velocities.* **E. Gehrcke.** (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 669–672, Aug. 15, 1913.)—Remarks upon the partition of energy between gas molecules and electrons. Two graphs are plotted on the same diagram; one is $y = x^2 . e^{-58x^2}$, and represents Maxwell's law; the other is $y = x^4 . (e^{ax^2} - 1)^{-1}$, in which the a is unity. This is practically coincident with the first for small values of x, but for larger values (*i.e.* beyond the maximum y) this second curve falls more rapidly and departs considerably from the first. From this second form, and other considerations, the author reaches the well-known radiation formula $\phi(\lambda, \theta) = c_1/[\lambda^5 (e^{c_2/\lambda\theta} - 1)]$.
E. H. B.

1979. *Statistical Mechanics and Probability of a Complexion.* **P. Hertz.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 2. pp. 177–196, 1913.)—Mathematical treatment of this thermodynamical problem. E. H. B.

1980. *Mechanism of Black Radiation.* **A. Korn.** (Phys. Zeitschr. 14. pp. 632–633, July 15, 1913.)—Introduces the Maxwellian distribution of velocities into the conception of pulsating electric charges, and obtains a time function of their velocity which, like Planck's radiation formula, yields Wien's law for high frequencies and Rayleigh's for low frequencies.
E. E. F.

1981. *Deviations from the Law of Partition of Energy.* **J. D. van der Waals.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 84–90, Sept. 3, 1913.)—A probable formula, consistent with what is known of kinetic energy, is suggested for a special case of deviation from the partition law for a distribution in configuration, such as the author called attention to in his preceding paper [Abstract No. 1696 (1913)]. This formula is employed to derive one for the dissociation equilibrium of diatomic gases which shows a certain analogy with the results of Nernst's Wärmetheorie. G. W. DE T.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1982. *Electric Effect of a Magnetic Insulator Rotating in a Magnetic Field.* **M[arjorie] Wilson** and **H. A. Wilson.** (Roy. Soc., Proc. Ser. A. 89. pp. 99–106, Aug. 19, 1913.)—In a previous paper H. A. Wilson showed that when an insulator of dielectric constant K rotates in a magnetic field there is an e.m.f. induced in it equal to that in a conductor multiplied by $1 - K^{-1}$. The object of the present work was to measure the induced e.m.f. in a magnetic insulator rotating in a magnetic field parallel to the axis of rotation. According to the theory based on the "principle of relativity" this induced e.m.f. should be equal to that in a conductor multiplied by $1 - (\mu K)^{-1}$, where μ is the magnetic permeability of the insulator, whereas in the theory of H. A. Lorentz and Larmor, the appropriate multiplier appears to be $1 - K^{-1}$, as for a non-magnetic insulator. No insulator is known for which μ differs appreciably from unity, so that it was necessary to construct a model of a magnetic insulator. It consisted of wax in which a large number of small steel spheres were embedded. The spheres were $\frac{1}{8}$ in. in diam. and each one was coated thinly with sealing-wax. The coated spheres were packed tightly and melted paraffin wax poured in to make a solid mass. The value of K for this insulator was 6 and that of μ was 3. Thus $1 - (\mu K)^{-1} = 0{\cdot}944$, and $1 - K^{-1} = 0{\cdot}83$. The ratio of the observed effect to that in a conductor was 0·96. Hence these experiments confirm the theory of relativity, but do not necessarily conflict with the fundamental assumption of the theory of H. A. Lorentz and Larmor, as possibly their value would not apply to the composite medium employed here. E. H. B.

1983. *Electron Theory of Thermo-electricity.* **J. M'Whan.** (Roy. Soc. Edinburgh, Proc. 23. pp. 169–176, 1912–1913.)—The preliminary argument of this paper may be summarised thus :—Incandescent bodies have been found, speaking generally, to emit negative electrons with great readiness, the saturation current of emission of electrons being found to be a definite function of the absolute temperature. H. A. Wilson regarded this emission of electrons as an evaporation of negative electricity through the surface of the hot body, determined by the nature and temperature of the body and by a definite "vapour pressure of electrons." This view is then worked out mathematically, and it is hoped to test the results experimentally. [See Abstract No. 1639 (1910).] E. H. B.

DISCHARGE AND OSCILLATIONS.

1984. *Current Curves in Ionised Air.* **E. Wertheimer.** (Phys. Zeitschr 14. pp. 711–717, Aug. 1, 1913.)—Since current curves in air ionised by X-rays have been obtained by Seemann [Abstract No. 1565 (1912)] and those with α-rays are well known, the author has studied the current- and potential-curves in the case of ionisation by β- and γ-rays, avoiding secondary radiation as much as possible. He used a Kleiner electrometer [Abstract No. 1201 (1913)] giving 4692 mm. per volt, and a Bronson resistance of

$2{\cdot}06 \times 10^{11}$ ohms. The curves obtained are compared with the approximate formula of Greinacher and the accurate formulæ of Mie. The recombination coefficient is seven times greater than that assumed by Mie. This is attributed to the circumstance of the ionisation not being homogeneous (ions equally distributed in the chamber) as assumed by Mie. E. E. F.

1985. *Quantum Theory and Emission of Electricity from Hot Bodies.* **W. Wilson.** (Phys. Soc., Proc. 25. pp. 331–335; Discussion, p. 335, Aug., 1913.)—For the purposes of this paper Planck's formula is put in the form—

$$I\nu d\nu = C\nu^3 \frac{d\nu}{e^{h\nu/kT} - 1}$$

in which $I\nu d\nu$ denotes the energy within the frequency limits ν and $\nu + d\nu$ emitted per sec. by the "resonators" of the radiating material, T is the absolute temperature, C a suitable constant, and h and k the universal constants of nature which are taken as—

$$h = 6{\cdot}415 \times 10^{-27} \text{ erg-sec.}$$
$$k = 1{\cdot}34 \times 10^{-16} \text{ erg per degree.}$$

The latter constant is identical with the absolute gas constant reckoned for one molecule. It is possible, therefore, to deduce from measurements on black radiation the number of molecules of an ideal gas per cm.^{3} under standard conditions of pressure and temperature. Planck thus finds $N = 2{\cdot}77 \times 10^{19}$. A further consequence of this theory and the results of electrolysis makes $e = 4{\cdot}67 \times 10^{-10}$ e.s. unit. Following up this theory, and applying it to the case in question, the author obtains a formula connecting the thermionic current and the temperature of the emitting body. This closely resembles Richardson's formula and agrees slightly better with experimental results.

J. W. Nicholson thought that Planck's constant h was in some way an electron constant, and that the emission of energy was discontinuous because the emission of electrons was discontinuous. E. H. B.

1986. *Influence of Oxygen on the Selective Photo-effect of Potassium.* **R. Pohl** and **P. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 625–636, Aug. 15, 1913.)—When pure potassium is brought in contact with oxygen at low pressures a dark-coloured surface layer forms, which appears to be of a colloidal nature consisting of particles of potassium suspended in a potassium-oxygen compound. It is extraordinarily sensitive photoelectrically to visible light; so that in the violet part of the spectrum an output of 240×10^{-4} coulomb per incident light-calorie can be observed. The maximum of this selective power of excitation is, compared with that of pure potassium, displaced about 7 % towards the shorter wave-length, viz., from $\lambda 436\,\mu\mu$ about to $\lambda 405\,\mu\mu$ about. At the same time there is produced in the ultra-violet, below $\lambda 280\,\mu\mu$, a very strong rise of electronic emission in the direction of higher frequency, which probably corresponds to the normal photo-effect of a potassium oxide. A. E. G.

1987. *The Long-wave Limit of Normal Photo-effects.* **R. Pohl** and **P Pringsheim.** (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 637–644, Aug. 15, 1913.)—The experimental results which have been obtained appear to prove that the long-wave limit of the photo-effect serves as a measure of the combination of the electron to a molecule acted upon by light. Still, opposed to the experimental results which have been obtained, in accepting this limit as a quantitative measure of the work of separation of the electrons, there is the difficulty that the long-wave limit of the normal effects with many metals and alloys is subjected to a fluctuation of an octave or more, at the same time it is not possible to state what influence on and in the extremely thin surface boundaries of the metals, in which the absorption of light occurs, is responsible for the displacement of the long-wave limit. A. E. G.

1988. *Observation of Variations of Photoelectric Effect.* **P. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 705–709, Aug. 30, 1913.)—In this paper a method is described by which variations of the photoelectric effect may be followed. The method makes use of a sensitive negatively charged point projecting axially inside a small copper cylinder, and is thus similar to Geiger's method for counting β-rays [Abstract No. 1873 (1913)]. A small hole in the side of the cylinder admits the light, which falls on the charged wire. In pure nitrogen, with a positively-charged point, the momentary charges appear on illuminating the electrode, so that with this arrangement the variation of the photoelectric effect for solid or fluid materials can be observed. [See also Abstract No. 2091 (1907).] A. W.

1989. *Anomalous Anode-falls and the Formation of Anode Rays.* **O. Reichenheim.** (Deutsch. Phys. Gesell., Verh. 15. 15. pp. 658–668, Aug. 15, 1913. Communication from the Physikal.-Techn. Reichsanstalt.)—Extraordinarily high anode-falls have hitherto been observed with strongly electronegative gases and vapours by the author and others [see Abstract No. 1089 (1909)]. Raisch [Abstract No. 375 (1912)] attributed the abnormality in the case of chlorine to the fact that the anode is acted upon chemically by the gas, the high fall of potential being caused by the badly conducting layer thus formed on the anode surface. The author, after pointing out that this explanation is not in keeping with facts concerning the production of anode rays, describes experiments which show that the fall of potential takes place in the gas itself, and that the abnormal fall is due simply to the decrease in the size of the effective anode caused by the chemical action. Anomalous anode-falls up to 100 times the normal could be obtained in iodine, bromine, air, hydrogen, and helium by decreasing the size of the anode sufficiently. These anomalous anode-falls obey laws similar to those obeyed by anomalous kathode-falls, viz., increasing with decreasing anode-surface, with reduction of pressure, and with increasing current. By means of the large anode-falls produced in the manner described or by means of the high potential-fall in the neighbourhood of a very fine constriction in the discharge, anode rays are produced even in electropositive gases such as hydrogen and helium, which further shows that the anomalous anode-falls are falls of potential in the gas and not in an insulating or double layer on the anode. F. J. H.

1990. *Electric Currents through Air Films.* **A. Anderson.** (Phil. Mag. 26. pp. 351–358, Aug., 1913.)—Two brass bars with carefully worked plane ends of area 1·15 cm.^{2} are mounted firmly on paraffin blocks stuck on a copper plate, so as to include between them a rectangular film of air of a uniform thickness of about 0·002 cm. Currents between two such bars are produced by very small p.d's., and increase with the applied voltage, for pressures up to about 80 volts, approximately according to Ohm's law, after which the increase in current is much more rapid than the increase of voltage. Everything points to the formation of ions in the surfaces of the film of air in contact with the ends of the bars, which ions become available as carriers when the opposing surfaces are close enough. These ions can be removed by removing the air, and when the air is introduced again they are again formed, but not instantaneously. Their formation requires time. It is probable that such layers of ions exist at the surfaces of all bodies in contact with the atmosphere, and that they play a prominent part in coherer action and in all cases of the discharge of bodies by contact. A. E. G.

1991. *Hysteresis in Vacuum Tubes.* **K. Fischer.** (Phys. Zeitschr. 14. pp. 708–710, Aug. 1, 1913.)—When in a vacuum tube the current is gradually increased and then allowed to fall from the highest attainable value, a hysteresis loop is obtained. The returning branch is below the original characteristic in the case of higher pressures, and above it in the case of lower pressures. The former the author calls positive, the latter negative, hysteresis. Between those two pressures there is a region of no hysteresis. The hysteresis does not produce any permanent changes in the tubes, and for small currents the ascending and descending branches coincide. The hysteresis is practically independent of the purity of the gas, but greatly affects the appearance of the discharge, complete stratification only being observed in the case of negative hysteresis. The two branches of the double characteristic give different positive columns, with different lengths and numbers of strata. These hysteresis phenomena are probably connected with those observed in the arc discharge. E. E. F.

1992. *Observations of the Afterglow.* **B. Thieme.** (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 794–796, Aug. 30, 1913.)—The author in a preliminary communication describes briefly several new observations bearing on the afterglow produced in the gas of a low-voltage carbon-filament lamp after a discharge has been made to pass, by placing it in an alternating field of high frequency (Tesla field). He concludes that the afterglow is a periodic discharge occurring about 30 or 40 times a second, the period becoming smaller the longer the duration of the effect. Experiments on the discharge which occurs when the bulb of the lamp is electrified by friction are also described, the conclusion again being that the discharge is periodic. Further experiments are being made which will be fully described in a later communication. F. J. H.

1993. *Effect of a Low-potential Current upon Photographic Plates.* **H. V. Gill.** (Roy. Dublin Soc., Proc. 14. 5. pp. 74–78, July, 1913.)—A considerable amount of experimental work has been done concerning the nature of the electric discharge, by causing sparks to pass over the sensitive surface of dry photographic plates. The question naturally arises whether the record obtained on development of the plate is to be attributed to some electric reaction, or simply to the luminosity of the discharge. For this reason experiments are now undertaken with currents which certainly are not luminous to determine the part played by the purely electric elements of the discharge. The plates are soaked in clean water for 5 or 10 minutes, and are then pressed for a moment between sheets of clean blotting-paper to remove any superfluous water from front and back. The electrodes are coins or other flat pieces of metal connected by wires to the terminals of a battery of storage cells giving a p.d. of 400 volts. These coins are placed on the gelatine surface of the plate and kept in position by wooden clips; the "exposure" occupies about 10 minutes. In general it is found that the effect produced at the kathode does not depend on the nature of the metal employed, and is less marked than that at the anode, but is present even when no blackening is produced at the anode. The kathode effect consists of a number of ray-like projections stretching out on the side facing the anode, being much less or altogether absent, on the more distant side. This is accompanied by a slight blistering of the moist gelatine surface, as if gas has been liberated. The effect at the anode is characteristic of the metal used as electrode, and appears to consist of two reactions, both of which are not always observed. One of these reactions appears to be common to all metals, and does not of itself result in a blackening of the plate on development. It may be observed in the red light of the dark room during process of exposure. It consists in a slight swelling of the gelatine surface of the plate, which swelling is seen to extend more or less uniformly around the anode. The other effect is apparently connected closely with that just referred to, but is not always present. This second reaction results in a blackening of the plate on development. The rate at which these effects spread out gradually falls off, and at the same time the current decreases. The falling-off of the current seems to be due to some polarisation effect, and explains the fact that an exposure of 10 minutes produces almost as marked an effect as one of an hour's duration. Sometimes there is a metallic deposit at point of contact of the anode. The following metals are tested as anode, and the peculiarities observed are given : Cu, Ag, Fe, Ni, Pt, Bi, C, Co, Cd, Zn, and a gold coin. Photographs of results are also included. As a whole the results of the experiments suggest the possibility of their being connected with the reactions studied by Lodge, Whetham, and others in gelatinous and other solutions, and are no doubt due to some reaction of metallic ions on the sensitive salts contained in the coating of the photographic plates. A. E. G.

1994. *Effect of Change of Diameter on the Potential Difference of a Discharge Tube containing Neon.* **G. Claude.** (Comptes Rendus, 157. pp. 432–435, Sept. 1, 1913.)—Alternating currents were sent in turn through a number of discharge tubes 5 m. in length and varying in diam. from 5·2 mm. to 45 mm. The pressure, 2 mm. of mercury, was the same for all, as was also the current density, with the exception of that in the smaller tubes in which larger current densities were required to maintain the discharge. With small tubes, however, the p.d. varies but little with the current density. The values of the p.d., diminished by 350 volts for the fall at the electrodes, when plotted against the diam. give a rectangular hyperbola, the equation to which is $y = 4800/x$, where y refers to the p.d. per m. of tube and x to the diam. in mm. This result is corroborated by the known fact that in the striated discharge the distance between successive striæ never exceeds the diam. of the tube. An additional experiment at 1·8 mm. pressure confirmed the above result. F. J. H.

1995. *Action of a Magnetic Field upon the Electric Discharge through Gases.* **L. T. More** and **S. J. Mauchly.** (Phil. Mag. 26. pp. 252–267, Aug., 1913.) —The authors, after reviewing Righi's work on the action of a magnetic field upon the discharge in a vacuum tube [see Abstract No. 561 (1912)] bring forward several points which are difficult to explain upon the neutral doublet theory advanced by Righi. As the result of experiments with a new modification of Righi's apparatus in which a lime kathode is used for the discharge, they are forced to abandon his theory and offer a fairly accurate and much simpler explanation, viz., that the effect of the magnetic field is just that of displacing the discharge from the kathode and of magnifying it so that its various parts seem to be changed. Under certain conditions of pressure, potential, and temperature of the lime kathode, all the phenomena observed by Righi with the magnetic field can be reproduced in a large tube arranged behind the lime kathode without the magnetic field at all, simply by earthing the kathode and a gauze screen surrounding the tube. The main actions of the magnetic field are (1) to reduce greatly the potential drop at the kathode, (2) to concentrate the discharge to one or more bright streams from the kathode, and (3) to force the electrons to move away from the kathode in helical paths. These features, with the exception of the fact that the electrons move in straight instead of helical paths, are characteristic of the lime kathode discharge. The conical shape of the luminous column called by Righi the "magnetic rays" cannot be explained on the doublet theory, but receives a ready explanation in the fact that the electrons are moving in coincident magnetic and electric fields, the latter being more concentrated along the axis of the tube and the former diminishing more rapidly than the latter. The intermittency of the induced discharge is found to be a feature of that produced with the lime kathode as well as of that produced by a magnetic field, which thus disproves Righi's statements that a magnetic field is necessary for a periodic discharge, and that the doublet theory alone will explain it. The periodicity can be regulated by an adjustment of the conditions and seems to be due to the accumulation of electrons at the kathode until a critical point is reached, when the discharge ensues, ceasing immediately after, however, until the requisite number of electrons have again accumulated. A virtual anode in the "induced column," the existence of which is emphasised by Righi in support of his theory, is also obtained without a magnetic field. A complete Crookes' tube discharge is found to exist on the side of the kathode remote from the anode and a virtual anode is produced whenever the positive column of this discharge is forced into the large tube. In order to effect this Righi had to use a magnetic field, but the authors find that it can be done by earthing the lime kathode and the gauze screen. Under these conditions a current of electricity is found to be passing from the earth into the interior of the tube through the glass walls. A number of diagrams illustrating the various types of discharge obtainable are included in the paper. F. J. H.

1996. *The Deposit upon the Poles of Metallic Arcs.* **W. G. Duffield.** (Phil. Mag. 26. pp. 333–345, Aug., 1913.)—The paper describes some remarkable growths of organic appearance which the author has observed upon the poles of the electric arc when viewed under the microscope through coloured glass. The observations were made chiefly with horizontal poles of copper, iron, and silver, and various combinations of these with each other and with carbon. The outstanding features of the growths are (1) their easier formation on the kathode than on the anode, (2) their formation upon a third electrode placed just above the arc, if its potential be sufficiently high and especially if it be negative, the latter being the only case in which the phenomenon occurs with silver, (3) their easier formation on a pointed electrode, (4) their derivation from the material of either the anode or the kathode but chiefly from the latter, (5) their organic form which is different for different metals, (6) the rapidity of their development as they approach the anode or when an outburst of vapour occurs, (7) the increasing difficulty of their formation with increasing atomic weight of the metal. Three lines of argument are developed to account for the phenomena and to explain the predominating influence of the kathode. (*a*) The gases rising from the metallic arc are ionised, the ions having vapour condensed upon them and chiefly upon the negative ions. The positive ions which thus have a larger mobility than the negative ions, are carried on to the kathode by the field which is insufficient to sweep out the negative ions. With silver, even the positive ions on account of the high atomic weight cannot be removed except by increasing the field considerably by the aid of a third electrode negatively charged. The negative ions of copper and iron can be removed by a third electrode raised to a high positive potential. (*b*) The kathode discharges electrons both on account of its high temperature and by the action of ultra-violet light, which electrons form nuclei for the condensation of the rising and rapidly cooling vapour. Particles near the kathode, although negatively charged, will be attracted by it and held by cohesive forces. (*c*) The ultra-violet light acting upon the particles of vapour above the arc promotes the emission of electrons and leaves them positively charged. They will thus migrate towards the kathode. The branch-like character of the formations is attributed to the action of points in promoting growth by reason of the larger field in their neighbourhood, which field is also responsible for the rapidity of the growths there. The difference in the nature of the growths for different metals is thought to be due largely to the difference of the flexibility of the filaments formed. The fact that the material of the growths is derived chiefly from the kathode indicates that the anode of the arc is not the only source of positive ions. These may be generated by the collisions of the electrons ejected from the kathode with particles of vapour derived from the same. A number of photographs illustrating the phenomena are appended. F. J. H.

1997. *Energy and Resistance of Sparks caused by Closing and Breaking Electric Circuits.* **O. E. Günther.** (Ann. d. Physik, 42. 1. pp. 94–132, Aug. 26, 1913. Abbreviated Dissertation, Leipzig.)—The heat generated by sparks due to making and interrupting an electric current is determined by an air-thermometer. The current circuit is closed and broken by means of a special contact which is carefully described. The p.d. was varied from 4 to 100 volts and the current from 0·2 to 1 amp. When a capacity is connected in parallel with the contact, the energy of the spark on *closing* the circuit agrees with that to be expected from theory and the resistance of the spark would appear to be a constant. With no capacity parallel to the contact the resistance of the spark made by *interrupting* the current appears as a function of the speed of interruption. This is shown by oscillograms which give results agreeing with those of the air-thermometer. When no capacity is parallel to the contact the spark on interruption is of the nature of an *arc*. A condenser placed parallel to the arc suppresses the *arc*, and a *spark* discharge takes its place. The larger the capacity the smaller the spark on breaking the circuit and the larger the spark on closing it. The curve connecting the capacity with total spark-energy on both making and interrupting shows a minimum energy for a particular capacity. A formula for the calculation of this capacity is given. An oscillogram shows the increase of spark-resistance with oxidation of the place of contact. T. P. B.

1998. *Current in Tuned Secondary Condenser Circuit assuming that the Oscillation in the Primary Circuit falls off Linearly.* **E. Taege.** (Deutsch. Phys. Gesell., Verh. 15. 16. pp. 753–772, Aug. 30, 1913.)—A mathematical paper which deals with the form of the oscillation in the secondary of two coupled condenser circuits, the oscillation in the primary circuit being assumed to fall off linearly: the condenser circuits are supposed to be in resonance. The investigation is also extended to the case when the oscillation in the primary circuit is suddenly interrupted by the quenching of the spark. T. P. B.

1999. *Electromagnetic Waves and the Mode of their Propagation.* **G. W. O. Howe.** (Electrician, 71. pp. 965–969, Sept. 19, 1913. Paper read before the British Association, at Birmingham. Elect. Rev. 73. pp. 486–489, Sept. 26, 1913. Abstract.)—The paper gives a simple method of making clear the mode of propagation of electrical energy. If power be transmitted by two wide strips of thin copper placed face to face and close together, the magnetic and electric fields will be approximately uniform throughout the space between the strips in any plane normal to the direction of transmission. Such a transmission line therefore proves an excellent method of approaching such conceptions as are involved in Poynting's theorem and electromagnetic wave phenomena. After a consideration of the continuous-current case, the paper deals with transmission of energy by alternating current and so ultimately with wireless telegraphy waves. In this last case the strips become discs. The electric and magnetic fields in the neighbourhood of the lower disc are identical in their nature with those near the earth but the variation with the distance from the generator is different. The want of agreement may be removed by making the height of the upper disc vary directly as the distance from the centre. The inductance and capacity per radial cm. of this transmission line are constant as is the case with the strips considered above. If this arrangement of inverted cone and lower disc is to give a correct representation of the actual radio-telegraphic waves, it is shown that the angle between the conical surface and the disc must be 85°. Stress is laid upon the fact that the transmission of energy depends upon the simultaneous existence of the electric and magnetic fields. T. P. B.

2000. *Absorption of Electric Waves in Iron.* **K. F. Lindman.** (Ann. d. Physik, 42. 1. pp. 30–44, Aug. 26, 1913.)—The wave-length employed is 26 cm. The author builds up systems of circular resonators which are in resonance with this wave-length. The resonators are arranged in vertical columns about 10 cm. apart. He finds the energy transmitted through and reflected by these systems (1) when the resonators are made of copper, (2) when they are made of iron. The copper resonators both transmit and reflect the waves better than the iron resonators; the smaller transmission in the case of iron is, therefore, not due to better reflection. A reduction of the cross-section of the iron resonators by one-half does not affect the result in either case, so that the greater absorption in the iron resonators cannot arise so much from the resistance as from the magnetic property of iron. Reflection from an iron *sheet* is practically the same as from a copper *sheet*, but there is still a difference of 2 % in favour of the latter. Klemenčič's value for the permeability of iron for Hertz waves, viz. 100, would seem to be about correct. The author has not been able to detect the Kerr-effect with Hertz waves of 16 cm. wave-length. T. P. B.

2001. *Short-wave Electric Transmitters.* **G. Mie.** (Phys. Zeitschr. 14. pp. 723–725, Aug. 1, 1913.)—Remarks on the paper of Leimbach [Abstract No. 1486 (1913)]. The author maintains that Leimbach did not obtain any quenched spark with rod oscillators at all, but only the Hertzian oscillating spark. Even with spark-lengths of 0·02 mm. the sparks were probably oscillatory. No quenching takes place in air, because the air retains its conductivity too long. Good quenched sparks are obtainable in coal gas, but not in gases in which the spark cannot liberate soot. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2002. *Light Emission and Electric Conductivity.* **J. Koenigsberger.** (Phys. Zeitschr. 14. pp. 643–646, July 15, 1913.)—Experiments on conducting filaments made out of compressed Auer substance provided with Pt electrodes show that there is no polarisation, and that therefore the conductivity is of a metallic nature. It can be shown generally, on electronic principles, that metallic conductivity, as distinguished from electrolytic, is responsible for luminous emissivity at high temperatures. Substances with a metallic conductivity begin to be transparent towards the end of the visible spectrum on the red side, and are generally transparent in the ultra-violet unless there is selective absorption. For the time of describing the mean free path of the electron is greater than the period of the incident light, the light-energy stored by the electron is not damped and transmuted, but restored to the ether. This may produce a displacement of phase, but no absorption. What may be briefly called the "collision interval" (Stosszeit) amounts to about $1{\cdot}4 \times 10^{-14}$ sec. (Reinganum, J. J. Thomson). E. E. F.

2003. *Electrical Conductivity of Sulphur.* **M. Pigulewsky.** (Jurn. Russk. Fisik.-Chimičesk Obščestva, 44. 2. pp. 105–122, 1912.)—Not being satisfied with the experiments made and conclusions arrived at by previous workers, including Wigand [1909], in explaining the change in conductivity of sulphur at higher temperatures, the author states the precautions necessary in making observations. The author used specially prepared sublimed carbon as electrodes. A hard cylindric carbon was made red-hot by current with the help of a transformer. From the sawed pencil thin plates were polished and the ends of the carbons covered with electrolytically deposited copper and put for 2 or 3 days into distilled water. After a few hours the carbons withstood 400–500°; only traces of water are lost at such a temperature. The ends of the carbons were boiled in sulphur at not higher than 120°, and polished with dry emery dust. Such electrodes are incomparably superior to metallic ones. Three such split carbon plates were placed with mica sheets interposed, the distance between the electrodes being from 0·5 to 1·0 mm. The lengthened carbon pile with the mica was put in a copper setting and compressed by means of a screw and spring. The plates were then placed in a porcelain jar, the whole being enveloped in asbestos cardboard and inserted in an asbestos cylinder, the space between the walls being filled in with sand. Observations were taken with an Ayrton galvanometer of sensitiveness $1{\cdot}37 \times 10^{-9}$ amp., current being taken at 100 volts from a battery. The results depend upon the treatment of the sulphur prior to the test—namely, whether the sulphur has been heated over 150° or to only 114° to 115°. The last temperature has no influence on the changes in conductivity. The sulphur was therefore divided into two groups: (1) sulphur which has not been under a higher temperature than 150°; (2) sulphur which has for a longer period been heated at a temperature of 150° to 250° In the case of sulphur in crystals (puriss.) which was only heated to 117–120°, the conductivity rose with the temperature to near 150°, and afterwards decreased. The rapidity of change in temperature is also of influence. If the average rise of temperature is 5 deg. in 2 mins., the maximum of the curve is very inconstant and its temperature always above 150°. When heating is slow (especially at 120–160°) the maximum is reached at 140° and lower. Monkman had not noticed the maximum at 140–160°, but all the others have done so. The greatest difference between the author and Monkman is at 250–400°. At this point the resistance increases according to the author, whereas Monkman and Wigand found a decrease; this difference is probably due to the fact that these authors did not notice that the curve charge depends on the rapidity of the temperature change.

Group II.—In cases where sulphur had previously been heated to 150–160° its insulating properties disappear: thus at a low temperature (20–30°) sulphur is a good conductor.

The conductivity of sulphur which has been kept for some time at 170° and afterwards left at house temperature, does not remain the same. After a few days it increases, and this change lasts from 3 to 4 days, when it decreases, but it takes some time to return to its original state, and the length of time depends only on the temperatures which the sulphur was at before. Solid sulphur is therefore held to exist in three different states: Octahedral, prismatic, and amorphous. Octahedral sulphur at 170° becomes amorphous; also at a temperature of 40–50° sulphur, especially amorphous, changes into crystalline. Only octahedral is stable, and all the other kinds sooner or later get into this state. Thus we see that the electrical conductivity depends on the percentage of octahedral sulphur in the preparation.

Change in Electrical Conductivity of Sulphur Caused by Light.—Electrodes used in this research were made of Al, though they may be of lead, zinc, tin, etc. To determine the sensitiveness of sulphur to light the author used as a source of light a quartz tube lamp containing mercury, which took 30 volts, 3½ amps. The results obtained differed according to kind of sulphur used—crystalline or amorphous. In the case of the first, light did not exercise any effect upon the resistance. To increase the percentage of amorphous sulphur it was heated to 195–200° for 70 hours.

Galvanometer Deflection in mm.		Distance between Receptacle and Light Source in cm.
In the Dark.	Exposed to Light.	
20·0	39·5	10
20·0	35·0	15
20·0	31·5	20
19·8	28·8	25
19·8	27·0	30
19·5	25·0	35
19·5	24·0	40

I. P.

2004. *Current Induction in Vibrating Cylinders.* **J. Kern.** (Ann. d. Physik, 42. 2. pp. 460–484, Sept. 23, 1913. Extract from Inaug.-Dissertation, Zürich.)—A calculation of the damping effect caused by induced currents in a cylinder rotating about its axis (vertical) in a horizontal magnetic field. The motion is expressed by the equation for a damped simple harmonic motion, and the damping factor contains terms for the effects due to air and to the field. That due to the field is a function of the dimension ratio of the cylinder, and this function is expressed as a series, of which the first two terms are sufficient for calculations. The method is adapted for determining the variation of the conductivity of the cylinder with temperature. G. E. A.

2005. *An Electrical Phenomenon.* **A. A. Campbell Swinton.** (Nature, 90. p. 621, Feb. 6, 1913.)—The author has noticed that, using a high-resistance (5000-ohm) telephone receiver, one terminal of which is held in the hand, when the other insulated terminal is applied to any metallic object of considerable size in his house a singing noise is heard corresponding in tone to the sound obtainable from the supply mains (continuous current). The sound is obtained even from stair-carpet rods about 3 ft. in length, especially near the top of the house, but ceases in all cases when the main switch of the supply is opened. Even with the switch open, however, the sound is heard if the telephone receiver be connected between the water pipe and a wire-netting aerial situated above the roof of the house. L. H. W.

ALTERNATING CURRENTS AND MAGNETISM.

2006. *A Theory of Magnets.* **S. B. McLaren.** (Electrician, 72. p. 25, Oct. 10, 1913. Abstract of paper read before the British Assoc., 1913.)—After pointing out the difficulties in the way of modern electromagnetic theory, it is assumed that the electromagnetic field is defined by two vectors, E and H, *i.e.* the electrostatic and magnetic field intensities. The field is bounded by closed surfaces within which E and H do not exist. The space within these surfaces contains matter and outside them is ether. All formulæ are to be deduced from the principle of least action. The paper deals with the application of this principle and its results. G. E. A.

2007. *Temperature Coefficient of Kew Magnet.* **G. A. Shakespear.** (Roy. Soc., Proc. Ser. A. 89. pp. 220–231, Aug. 27, 1913.)—An experimental examination of the dependence of magnetic moment of a Kew collimator magnet on temperature from which the author concludes as follows :—(1) For a steady rise of temperature, the relation between the moment m_t at a temperature t° above some standard temperature, O, may be approximately, represented by an equation of the form $m_t = m_0(1 - qt - q't^2)$, where q and q' are constants, and for a subsequent steady fall a similar equation holds, but with different constants. (2) If the rise and fall of temperature be not steady, the relation cannot be represented by any such simple equation. (3) There is always, even for a change of temperature of only a few degrees, a residual weakening of the magnet, which diminishes with time, if kept at constant temperature, until after about 24 hours the original value is very nearly regained. (4) It seems desirable that for accurate work the temperature of the magnet should never vary more than a few degrees. (5) For differences of field of the order ±H the temperature coefficient is not sensibly affected by the field. E. H. B.

2008. *Conservation and Origin of Terrestrial Magnetism.* **K. Birkeland.** (Comptes Rendus, 157. pp. 275–277, July 28, 1913.)—The author having previously shown [see Abstract No. 1935 (1913)] how the motion of ions and electrons around the sun augments solar magnetism, now attempts to deduce the method by which the emission of solar electrons in space may give birth to terrestrial magnetism. He opines that a system of helio-kathodic rays exists at present round the earth. There is, for example in the equatorial plane, an annulus where the radiation circulates so as to augment terrestrial magnetism, but since such rays by their direct magnetic action cannot account for more than 1/40th of the terrestrial magnetic force it is necessary to investigate whether this external radiation system may create induction currents during the earth's rotation, which may explain the diurnal variation of terrestrial magnetism and even the general phenomenon of terrestrial magnetism. It is impossible, however, that such a system should give rise by induction to electrical currents always circulating in the same sense round the equator, but the external helio-kathodic radiation may produce induced currents which change in direction during the earth's rotation. Under certain conditions, given in the paper, the terrestrial magnetism will always be increased whatever the direction of the earth currents, provided these are nowhere sufficiently strong to de-orientate existing magnetism. Electronic whirls may be set up, and wherever such an electronic system in dynamic equilibrium receives a new electron, the conclusion drawn is that the electron will be caused by magnetic forces to turn in the same plane and direction as the others. The author discusses the question of the conservation of terrestrial magnetism, and remarks that when the magnetisable crust is thickened by cooling, the magnetic elements in the new interior strata formed have received an orientation which, by reason of the enormous pressures involved, cannot be modified. He has commenced experiments to see whether the hypothesis may be verified on a laboratory scale. The author then explains the origin of terrestrial magnetism as due to the assembly of rays about the earth to form an equatorial annulus, and that the general magnetisation develops by successive reinforcement. The author promises later to apply his theory to the case of the rotation which the magnetic axis executes about the geographical pole. H. H. Ho.

RADIOLOGY AND ELECTROPHYSIOLOGY.

2009. *Physiological (Retinal) Effect of an Alternating Magnetic Field.* **H. L. Jones.** (Roentgen Soc., Journ. 9. pp. 53–55, July, 1913.)—The behaviour of the retina to electric currents is peculiar. It is remarkably sensitive in one respect, and very insensitive in another. To stimulate it, the current requires to have a considerable duration, and a very long duration as compared with other irritable tissues, such as the motor nerves and sensory nerves. It is found that when condenser discharges are applied to the retina there is no response given with a capacity of 0·025 mfd. even with 100 volts although this produces a muscular contraction. With 0·05 mfd. a slight effect can be noticed, and if the duration of the discharge be doubled by inserting a resistance of 1000 ohms in series with the patient, a stronger visual effect is produced, although the insertion of the resistance reduces the energy of the discharge. With a resistance of 10,000 ohms and a condenser of 0.5 mfd. a visual effect is perceptible with 11 volts. The retina appears to be unable to respond to electrical stimuli which are less than 1/250 sec. in duration, and responds much better to waves which are very much slower, while motor nerves respond to impulses as short as 1/25000 sec. Reference is made to the work of S. P. Thompson, Peterson and Kennelly, Duchenne, Waller, etc. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2010. *New Element in the Atmosphere.* **F. W. Aston.** (Engineering, 96. p. 423, Sept. 26, 1913. Paper read before the British Assoc. at Birmingham.) —In his studies on the positive rays, J. J. Thomson obtained indication of the presence in the air of a body of atomic weight about 22 and giving a line next to neon, 20. The author has continued this work, and arrives at the conclusion that atmospheric neon is a mixture of two gases which are identical in all their properties with the exception of the atomic weight, which has the respective values, 19·9 and 22·1. By 8000 fractionations of the gas, or, better, by using the diffusion method in conjunction with a new quartz-disc density balance in which 0·5 c.cm. of the gas is weighed against oxygen, it is found that ordinary neon contains about 12·5 per cent. of the heavier gas, which does not appear to be a compound. The spectra of the two gases are apparently identical. T. H. P.

2011. *Electric Conductivity of Concentrated Aqueous Salt Solutions.* **A. Sachanov.** (Zeitschr. Electrochem. 19. pp. 588–589, Aug. 1, 1913.)—A preliminary communication. Having shown that certain anomalies occur in the molecular conductivity changes on dilution, and that these changes are influenced by the dielectric constant of the solvent when small, the author finds similar anomalies also on diluting aqueous solutions of typical binary compounds; but they appear already at very high concentrations, because the dielectric constant of water is very large. The conclusion is based upon experiments with $AgNO_3$, LiCl, $LiClO_3$, and on calculations deduced from the measurements of Kohlrausch and Sprung concerning NH_4NO_3, KBr, KI.

H. B.

2012. *Structure of Steel.* **S. V. Biélynsky.** (Rev. de la Soc. Russe de Métallurgie, pp. 396–420, 1912. Rev. de Métallurgie, 10. pp. 495–502, Sept., 1913. Abstract.)—A series of steels containing carbon percentages of 0·1, 0·4, 0·9, 1·4, 1·8, respectively, were examined as cast and chilled from the molten state, or cooled in the air, or cooled in the furnace. Sections of the ingots were etched in copper sulphate solution; in some cases the copper was subsequently washed away, and in others the steel was slightly rubbed by emery paper after removing the copper. The structures referred to are only such as appeared, after these preparations, to the naked eye or with a few diameters' magnification. The structure effects found are classified in considerable detail. The three main classes of structure, generally present more or less in superposition in all these cases are dendritic, network, and granular. The network structure is formed of secondary elements, ferrite and cementite, in a regular or elongated network, combined with a Widmanstätten structure. The granular structure is that most frequently studied; it is further pronounced to be similar to and identical with the fracture. Each of the three types is subdivided further, and the structures found are described in terms of these subdivisions. This will be best understood from the summary in the following two Tables, but the complete explanation of the subdivision symbols necessitates reference to the diagrams accompanying the original. Da is the dendritic structure. In the upper part of the ingot the axes of the first degree are longer than those of the second degree; in the lower part they tend to be nearly equal. R is the network or cellular structure. Ra type has regular (equiaxed) meshes throughout but smaller at the top than at the bottom of the ingot. Rb has small cells in the lower part of the ingot, and elongated cells in the upper part. Rc has local agglomerations in the inter-axial surfaces of the dendrites; the dendrites being distributed as in Da. G is the granular structure. Ga is irregular grains. Gb is irregular grains in the lower part and elongated irregular grains in the upper part of the ingot. Gc is regular grains (polyhedra). In 1DR the network pattern is independent of the dendrite pattern. In 2DR the network and dendritic patterns coincide. 3DR is practically the same thing as Rc, and is the limiting case.

TABLE I.

Carbon, per Cent.	Furnace-cooled.	Air-cooled.	Water-quenched.
0·1	Da, Ra, Ga, 1DR	Da, Rb, Gb, 2DR	(Da), (Rb), (Gb), 2DR
0·4	— — Gc, 1DR	— — Gc, 2DR	Da, Rc, Gc, 3DR
0·9	— — — 1DR	— — — (2DR)	— — — 3DR
1·4	— Rb — 2DR	— — — 2DR	— — — 3DR
1·8	— Rc — 3DR	— — — —	— — — —

Table II shows the sizes of the respective structures in mm.^{2}. Amongst other deductions the author finds that the sizes of the several structures are inversely proportional to the carbon-content and to the speed of cooling. The network structure become less pronounced as the dendritic structure becomes more pronounced. The dendritic structure becomes more pronounced (though smaller) as the carbon-content increases.

TABLE II.

Carbon, per Cent.	Dendritic Structure.		Network Structure.		Granular Structure.	
	Furnace-cooled.	Air-cooled.	Furnace-cooled.	Air-cooled.	Furnace-cooled.	Air-cooled.
0·1	650	18	300	3·5	27	3
0·4	200	130	150	3·3	0·5	0·3
0·9	—	100	4	—	0·4	0·2
1·4	130	90	3	2·2	0·25	0·085
1·8	15	—	1	—	0·2	—

F. R.

2013. *Air-liquid Contact Potential Difference.* **G. W. Moffitt.** (Phys. Rev. 2. Ser. 2. pp. 95–103, Aug., 1913.)—From a review of previous work it is concluded that no experimental determination that is entirely free from objection has as yet been made of any electrode potential, or of any liquid-liquid p.d., and that the question of the air-liquid contact p.d. has merely been raised. The purpose of the present investigation was to devise a simple and satisfactory method for the study of contact p.d.'s in those cases where liquids enter into consideration, and to seek out and eliminate if possible the unknown sources of erratic error which have caused such discrepancy in the experimental results of previous investigators. The whole aim of the work was not realised, but enough has been done to show that the problem of contact p.d.'s with liquids is more complex than has been thought. A form of the compensation method was used, and the general existence of a p.d. at the air-liquid contact has been definitely shown. The air-liquid contact p.d. may vary as much as 0·8 volt, depending on the condition of the liquid surface. Water and the aqueous solutions used are more positive to the air when the surface is clean than when it is contaminated. The value of the air-liquid contact p.d. (for the solutions studied) is approximately the same for aqueous solutions of different salts at normal concentration. A. W.

2014. *Electrometallurgy of Aluminium. I. The Ternary System Alumina-Fluorite-Cryolite.* **P. Pascal** and **A. Jouniaux.** (Bull. Soc. Chim. 13. p. 439–449, 1913. Zeitschr. Elektrochem. 19. pp. 610–613, Aug. 15, 1913.)—The authors determine in nickel crucibles lined with graphite in Méker furnaces, the melting-points of cryolite 977°, fluorite 1361°, and alumina 2020° (estimated), and investigate the three binary systems and the ternary system. The ternary eutectic contains 59·3 per cent. of cryolite, 23 of fluorite, and 17·7 of alumina; it melts at 868°. The isothermals of the solidus are also determined. H. B.

2015. *Influence of the Addition to the Electrolyte of Free Sulphuric Acid and of its Neutral Salts upon the Kathodic Polarisation of the Cu | $CuSO_4$ Electrode.* **D. Reichinstein** and **A. Zieren.** (Zeitschr. Electrochem. 19. pp. 530–534, July 1, 1913.)—The kathodic polarisation of this electrode is qualitatively and quantitatively quite different in a neutral electrolyte and in an electrolyte containing a measurable $H^{\cdot}$ concentration. The polarisation is much increased by the addition of both free H_2SO_4 and of a neutral sulphate (Cu, Zn, Mg, K, Na, NH_4). From the nature of the current density-concentration curve it is concluded that the addition in the first instance suppresses the $Cu^{\cdot\cdot}$-concentration, and that secondly the slow reaction, on which the chemical polarisation depends, consists in the reduction of the $Cu^{\cdot\cdot}$-ions by a kathodic reducing agent, which is primarily produced, and not in any gradual replenishing of $Cu^{\cdot\cdot}$-ions from the undissociated $CuSO_4$ of the electrolyte.

H. B.

2016. *Electro-deposition of Gold and Silver.* **F. C. Frary.** (Amer. Electrochem. Soc. Trans. 23. pp. 25–97, 1913.)—A compilation of the various recipes which have been published for plating with gold and silver. In the electro-deposition of gold the following baths are dealt with:—Simple halide, cyanide, ferrocyanide, miscellaneous, containing little or no cyanide, baths for producing special colours. In the case of silver the baths dealt with are: simple salts, cyanide, baths for bright deposits, ferrocyanide, miscellaneous chloride baths, miscellaneous non-cyanide baths, baths for depositing silver alloys. T. S. P

2017. *Electro-deposition of Cobalt and Nickel.* **O. P. Watts.** (Amer Electrochem. Soc., Trans. 23. pp. 99–152, 1913.)—A compilation of the various recipes which have been published for the electro-deposition of cobalt and nickel. The subjects dealt with are: Electroplating with cobalt; deposition of an alloy of cobalt and nickel; electro-chemical analysis of cobalt and separation from nickel; electro-deposition of nickel; purity and passivity of nickel anodes; nickel-plating baths; malleable nickel; baths producing thick deposits; agents for the production of smooth deposits; nickel electrotypes; the nickeling of zinc; and the electrolytic estimation of nickel. T. S. P.

2018. *Electro-deposition of Lead.* **F. C. Mathers.** (Amer. Electrochem. Soc., Trans. 23. pp. 153–192, 1913.)—A review of the various methods which have been proposed for the electro-deposition of lead. The subjects dealt with are: Lead salts of the fluorine and perchloric acids; lead salts of nitrogen acids; lead salts of other inorganic acids; lead salts of acetic, oxalic, and other organic acids; alkaline electrolytes; electrolytes giving lead peroxide; non-aqueous electrolytes; miscellaneous; electro-plating and metal colouring. T. S. P.

2019. *Electro-deposition of Tin.* **E. F. Kern.** (Amer. Electrochem. Soc., Trans. 23. pp. 193–232, 1913. Chem. Engin. 17. No. 6. Chem. News, 108. pp. 57–59, Aug. 1, and pp. 68–70, Aug. 8, 1913.)—This paper is a compilation of data collected from the literature for the electro-deposition of tin. The subjects dealt with are: Electro-deposition by immersion; electrolytic estimation of tin; electro-deposition by separate current; conditions necessary to obtain bright, dense, and adherent deposits; electrolytic recovery of tin from tin-plate scrap and electrolytic treatment of tin ores; detinning by combined chemical and electrolytic methods; electrolytic refining of tin; effect of organic addition-agents in tin electrolytes. T. S. P.

2020. *Electro-deposition of Copper.* **C. W. Bennett.** (Amer. Electrochem. Soc., Trans. 23. pp. 233–250, 1913.)—A compilation of the various recipes published for the electro-deposition of copper from acid and alkaline electrolytes and from electrolytes containing addition-agents. T. S. P.

2021. *Electro-deposition of Brass and Bronze.* **C. W. Bennett.** (Amer. Electrochem. Soc., Trans. 23. pp. 251–260, 1913.)—A compilation of the various recipes which have been published for the electro-deposition of brass and bronze. T. S. P.

2022. *High-tension Electrolysis: A Method of Measuring High-voltage Currents.* **W. W. Strong.** (Amer. Chem. Journ. 50. pp. 213–218, Oct., 1913.)—A transformer serves as a source of alternating voltage ranging between 5000 and 60,000 volts. A graduated vessel contains Pt electrodes and a dilute solution of sodium hydroxide as electrolyte, and is connected in series with a corona wire; by the use of a rectifier the corona current may be made positive or negative. The results of the experiments showed that the gases given off at the electrodes were not in accordance with the volume ratio $2H_2 : O_2$, although the total quantity of gas evolved was of the order of magnitude to be expected from Faraday's laws. In many cases practically all the gas moved in the same direction as the electric current. If the electrolytic cell is placed on the grounded side of the corona discharge circuit, the electrolytic gas is given off in the same way as for low-voltage currents. T. S. P.